# THE FUTURE OF THE DEPARTMENT OF ENERGY'S MULTIPROGRAM LABORATORIES

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## HEARING

BEFORE THE

SUBCOMMITTEE ON
ENERGY DEVELOPMENT AND APPLICATIONS

AND THE

SUBCOMMITTEE ON
ENERGY RESEARCH AND PRODUCTION

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

NINETY-SEVENTH CONGRESS

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[*] On assignment to Budget Committee for 97th Congress.

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# THE FUTURE OF THE DEPARTMENT OF ENERGY'S MULTIPROGRAM LABORATORIES

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THURSDAY, DECEMBER 2, 1982

HOUSE OF REPRESENTATIVES, COMMITTEE ON SCIENCE AND TECHNOLOGY, SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS AND THE SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION,

*Washington, D.C.*

The joint hearing met, at 10:15 a.m., pursuant to call, in room 2318, Rayburn House Office Building, Hon. Marilyn L. Bouquard (chairperson of the Subcommittee on Energy Research and Production) presiding.

Mrs. BOUQUARD. The subcommittees will come to order.

I would like to apologize to our witnesses and those who are in the audience for our delay this morning, and I would also like to extend regrets from our chairman, the Honorable Donald Fuqua. He is not with us this morning because, as most of you know, we do have the nuclear waste management bill on the floor and it is necessary for him to be there at this time.

I would like to welcome our distinguished witnesses this morning, Dr. Trivelpiece, Dr. Bennett and Dr. Pry.

As you know, our subcommittees have always had as a major institutional concern the health and vitality of the DOE National Laboratory System.

We recognize the valuable contributions made by the laboratories to our national security and to our Nation's continued preeminence in science and technology.

I would like to draw to your attention, for example, the recent announcement by "Industrial Research and Development" magazine, and I have it here if you haven't seen it, of its 1982 product award winners.

These "I-R 100" awards are given each year for products judged on the basis of their importance, uniqueness, and usefulness from a technical standpoint.

Our Multiprogram National Laboratories won 11 of these awards this year. I am particularly proud to tell you that Oak Ridge National Lab tied for first place with General Electric by claiming six product winners.

I think all of us here today will agree that we need to preserve the Laboratories' special combination of knowledge, equipment, expertise and commitment to research and development that leads to achievements of this calibre.

We appreciate the efforts of the Department in initiating the ERAB Laboratory study, and we are grateful to the ERAB panel members for their efforts at identifying areas in which the Government can assist in improving the Laboratories' abilities to function efficiently.

I look forward to hearing your testimony and discussing your results and recommendations.

Thank you.

Without objection, the opening statement of our chairman, Congressman Fuqua, will be made a part of the record.

[The opening statement of Mr. Fuqua follows:]

### OPENING STATEMENT OF HON. DON FUQUA (D.-FLA.)

This morning the Subcommittee on Energy Development and Applications joins with the Subcommittee on Energy Research and Production to hold a hearing on the future of the Department of Energy multiprogram laboratories.

This hearing is the third in a series on the DOE laboratories held jointly by the Subcommittees during the 97th Congress.

Our first hearing, in July 1981, examined the general issue of DOE national laboratory relationships with industry and the universities. Subsequent to that hearing, I requested that the Office of Science and Technology Policy initiate a study of the entire civilian federal laboratory system. I am pleased that such a study has been undertaken by the prestigious White House Science Council and is being chaired by Dr. David Packard. The Committee looks forward to completion of the study early next year.

Our second hearing, in June of this year, dealt with the impact of continuing budget uncertainties on DOE's national laboratories. We learned of the difficulties facing the labs, not only in terms of funding cutbacks, but also in carrying out their planning and management functions.

The primary purpose of today's hearing is to review the results of a timely report from DOE's Energy Research Advisory Board. The report, released in September of this year, assesses the roles, capabilities, and management of DOE's large, multiprogram laboratories, such as Argonne, Brookhaven, Lawrence Berkeley and and Livermore, Los Alamos and Sandia. This report undoubtedly will be an important contribution to the Packard study of the entire federal lab system.

At today's hearing, we would also like to explore with our witnesses ways to foster greater cooperation between the labs and private industry. It is clear to most of us on this Committee that the DOE laboratory system is a true national resource of first-rate scientific talent and world-class research facilities. However, we must be assured that these labs are responsive to National needs, and that they work in harmony with industry and the universities.

To explore these issues we have a panel of three distinguished witnesses:

Dr. Alvin Trivelpiece is the Director of DOE's Office of Energy Research. Among his many duties, he is responsible for advising the Secretary of Energy on issues concerning the DOE national laboratory system.

Dr. Ivan Bennett, Dean and Provost of the New York University Medical Center, is the Vice-Chairman of the Energy Research Advisory Board (ERAB) and Chairman of the ERAB Multiprogram Laboratory Panel that prepared the report.

And, Dr. Robert Pry, Executive Vice President for R&D, Gould, Inc. is chairman of an Industrial Research Institute task force that is examining relations between industry and DOE's national laboratories. He is also a member of the ERAB Multiprogram Laboratory Panel.

Mrs. BOUQUARD. Dr. Trivelpiece, will you proceed with your testimony ?

I would also like to include the opening statements of Mr. Winn and Mr. Lujan, without objection.

[The opening statements of Mr. Winn and Mr. Lujan follow:]

### OPENING STATEMENT BY HON. LARRY WINN, JR.

Mr. Chairman, I appreciate the opportunity to participate in this hearing on the Future of the Department of Energy Multiprogram Laboratories.

In working with the Department of Energy and its predecessor agencies over the years, our committee has been continually reminded of the possibilities and the challenges associated with the National Laboratories. I do confine my remarks here to the Multiprogram Laboratories, excluding those involved in weapons R&D. During the past 50 years we have seen science advance on many fronts through the work performed at the National Laboratories involving fundamental research. This improved understanding of our world has given science and engineering strong foundations on which to work. We are certainly aware that at this time we see two important trends, which may work against each other. On the one hand our desires to maintain an orderly rate of scientific exploration call for increasing amounts of money. At the same time there are public and private pressures being exerted to reduce government funding. This does not necessarily mean that basic research will be eliminated, but it does mean that we must utilize these laboratory resources at maximum capability and efficiency. So this report by the Energy Research Advisory Board comes at a very important time.

In reviewing the report, we certainly have been impressed with its comprehensive nature. And some of the findings and recommendations require careful study. I am certainly pleased to find that the Board is impressed with the scientific and technological capabilities of the laboratories and the qualities and resourcefulness of laboratory leadership. On the other hand, the Board finds that DOE organizational inefficiencies and funding policies are obstacles to the full organization of laboratory capabilities. There are other, equally significant, statements in the report.

In addition to this report, we must consider other evaluations of the laboratories. For example, we hear from time to time that the laboratories, through certain procedures, appear to exclude industry and colleges and universities from participating in some research programs. We hear also that technology transfer is a difficult procedure from the laboratories to the private sector. Now, I will be the first to admit that these charges are somewhat vague at times and difficult to define. However, I also believe that presence of considerable smoke is indication that there may be some fire. So, certainly this committee would be interested in evaluating such reports. Maybe we will get some feel for that this morning and maybe it will require additional investigation on the part of the committee.

In any case, Mr. Chairman, I want to thank you for holding this hearing. I look forward to our continuing National Laboratory Oversight together and improved utilization of this very important national resource. Thank you.

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## OPENING STATEMENT OF HON. MANUEL LUJAN, JR. (R.-N. MEX.)

Thank you, Madam Chairman. I am pleased to join you in welcoming our witnesses this morning. As you know, I have long been a supporter of the National Laboratories. I am pleased that the Energy Research Advisory Board report has reconfirmed my view of the laboratories' contributions.

An important aspect to the success of the National Laboratory system is the strong interaction with industry and the universities. There are many good examples. At Sandia National Laboratory in Livermore, California, the Combustion Research Facility has been a model of successful interactions with industry, both on a domestic and an international scale. At Los Alamos National Laboratory in my own state of New Mexico, the Meson Physics Facility has a long history of intensive interactions, especially with the universities. Likewise, in my own district, Sandia National Laboratories in Albuquerque is the site of the Central Solar Receiver Test Facility that has been a focal point for interactions both with universities and industry. There are similar examples for each Laboratory such as the National Center for Electron Microscopy at Lawrence Berkeley Laboratory and the National Center for Small-Angle Scattering Research at Oak Ridge, in your own district, Madam Chairman. The most recent example, I am pleased to note, is the National Synchrotron Light Source at Brookhaven, which just last week had dedication ceremonies. This facility has the capability of providing electron beams to 44 experimental ports simultaneously, providing access for as many as 500–600 people.

Historically, there have been problems in interactions of the National Laboratories with industry and the universities. We have made great strides in resolving many of the problems, and the situation now is greatly improved.

However, we still need to do more to encourage the optimal interactions of the National Laboratories with industry in the universities. I especially agree with the Energy Research Advisory Board's recommendation that the procedures for management of the National Laboratories by DOE and the procedures for contracting should be improved. There is also room for more improvements in the area of patent policies, although ERAB may be correct that a large part of this problem is due to failure to recognize the changes that have already been made. In general, the area of technology transfer should be looked at more closely, especially in regards to the present conflict-of-interest rules for industry.

This hearing represents a major step in the right direction. I am delighted that the witnesses could join us today, and I hope these discussions will help us define how we can best improve interactions between the National Laboratories and the industry and universities so that we make maximum use of the invaluable resources that the National Laboratories represent.

Thank you, Madam Chairman.

Mrs. **Bouquard**. Please proceed.

## STATEMENT OF ALVIN W. TRIVELPIECE, DIRECTOR, OFFICE OF ENERGY RESEARCH, DEPARTMENT OF ENERGY

Mr. **Trivelpiece**. With your permission, I would like to have my prepared statement placed in the record.

Mrs. **Bouquard**. Without objection, your complete testimony will be made a part of the record. You may summarize as you wish.

Mr. **Trivelpiece**. It is traditional to say how pleased one is at an opportunity to testify. I will certainly go along with tradition. In this case perhaps it is even more relevant than in most cases because I don't believe there are any particularly contentious issues in this case.

We do appreciate the chance to talk about the National Laboratories. We share with this committee the concerns for the health and well-being of the National Laboratories, and for insuring that they are run well. One aspect of this is to insure that the funding provided has sufficient continuity. This is to guard against the roller coaster phenomenon that sometimes comes in as programs come and go out of fashion. That is a rather destructive way to have those laboratories managed and run. We do share your concern. We appreciate this opportunity to talk to you about where we are with respect to the laboratory study that was done.

The stimulus for this study, in fact, has as one of its watershed events hearings that were held by the committee a little over a year ago. That hearing was held, I think, in response to some of the things that were happening to the laboratories at that stage. There were a changing set of national conditions, economic conditions and other conditions affecting R&D policy. As a result of that the Deputy Secretary initiated a study urging that the Energy Research Advisory Board, which we refer to as ERAB, take a look at the roles of the laboratories. In other words, ERAB was to review what the laboratories are doing, and do they do their job well? Can we help them? Are we hindering them in any way? In what ways can we help them more?

Well, the study that was initiated by the Deputy Secretary has been recently completed. I want to take the opportunity to compliment ERAB for an excellent job.

I think there are many things in their report that we agree with and we will talk about some of those today.

I also want to thank and compliment the committee for its concern for the laboratories that stimulated the Department to undertake this kind of a study. I think it is very important. This committee has played a very important role in insuring to the health and well-being of the laboratories. In fact this responsibility goes back to 1975 when the Energy Research and Development Administration was created and this committee then became the oversight committee for the National Laboratories. You have done an excellent job in supporting the laboratories over this period of time.

What I want to do is to describe first the process by which we have taken the report from ERAB and where we are with respect to formulating our opinion on the recommendations. We received the report in September. We have reviewed it internally. We delivered it to the DOE Operations Office managers, to the laboratory directors and to the program assistant secretaries in the Department. Each of them provided for us their opinion on the report and its recommendations. We have collated those in the various categories into which the recommendations have been made. In effect, this results in essentially three categories. There are a collection of things that are noncontroversial. They are good ideas. We agree with them. In many cases they are things we are already doing or things that we can do that do not necessarily require additional internal review and/or approval.

There are other things that they have suggested in recommendations ERAB has made which require some additional study. We will take those additional studies into account before deciding on the best course of action.

There are other recommendations which will require the review of Secretary Hodel. I would like to make a brief disclaimer, in a sense. When this hearing was originally scheduled, Secretary Edwards was still Secretary of Energy. The report was being prepared for him, and our analysis of it was going to come to him for review. The testimony would have contained a final departmental position, or at least very close approximation thereto.

Of course in the meantime, the President has in the recess appointed Secretary Hodel. He had his confirmation hearing yesterday and I assume he will be confirmed rapidly. I certainly hope so. In any event, the press of business leading to his getting prepared for his confirmation hearing has made it necessary to not bring this particular matter to his attention in a detailed way. Therefore, what you will hear from us today is a summary of the material that will constitute the input to the Secretary for his review, noting those areas that will require his particular attention.

Now, in the first category of recommendations, ERAB has commented on the roles and missions of the laboratories. They also note the Department should try to make sure that we are continuously reviewing the roles and missions of laboratories, taking into account both the changing needs in national programs and the laboratories needs.

We agree with ERAB's suggestion that we should improve the institutional planning process. The institutional planning process involves having the laboratories prepare a plan in which they identify those activities over as 5-year period which they think are important and that they should be engaged in. We in headquarters review their plans and make suggestions back to them on areas where we think it is likely that they will be successful in receiving support from the Department.

There is a suggestion that we should implement a lab appraisal process. We are trying to do that. ERAB also suggests that the laboratory director should be more heavily involved in the policy recommendation aspects of helping the Department develop its R&D positions.

We have discussed this with the laboratory directors. We believe that we are probably to the extent allowed by law taking advantage of the opinions of the laboratory directors in an appropriate manner. In fact most of the laboratory diseases, when asked, did not complain that their input is not being taken into account. In addition to other channels for input, I do have, periodically, laboratory directors meetings. We do listen to what they have to say. I think for the most part they probably do have a more or less adequate opportunity to make their interests known to us.

There were some comments on the use of a lead mission assignments for laboratories. We are doing that. In some cases it is quite appropriate and in other circumstances it probably is not. It is a useful management tool and we try to use it where appropriate.

ERAB commented concerning the optimal use of existing research facilities. We agree those should be used in a cost effective manner, and that we should continue to provide the facilities for university and/or industry as might be appropriate.

ERAB suggests that we should publicize our liberalized patent policy more than we have. In some of the backup material for today's testimony is a summary of the change in DOE policy regarding patent waivers for work for others. We have essentially reversed the sign of the patent waiver circumstance with respect to outside users using facilities at the National Laboratories. It used to be that if somebody wanted to use our facilities and retain patent rights they had to apply for a waiver. I had the good fortune to arrive in the Department and be involved in changing the rule, such that now the waiver is granted automatically unless the government decides to retain its rights. That single step has improved the climate with respect to outside users using our facilities in a way that is quite remarkable.

The need for essentially an internal research and development fund for the laboratories was suggested. We agree with that and, in fact, we are already in the process of preparing a draft DOE order which will tend to regularize the approach, by having essentially an IR&D function as an allowed overhead expense within the laboratories activities.

There are other things which, as I said, require some outside study or further action before we could implement them. One of these was the suggestion that there should be a 2-year rolling appropriation by Congress. From my own experience in doing research I can certainly say that a better degree of stability is provided if you have some idea a year or two in advance of exactly what the funding situation is likely to be for your own area of research. If that could be done that would certainly be a useful thing. We support it and if legislation is required we would be delighted to help in anyway to bring that about.

There was also an ERAB recommendation that we should review some of the reporting requirements. We are in the process of assembling a group within the Department to look at the reporting requirements now and see what, in fact, we are requesting of the laboratories. We plan to do an inventory and then based on that, try to come to a conclusion as to what reports should be reduced. We will involve the laboratories in that process.

There are other areas that are going to require the Secretary's specific review and attention. Those recommendations that involve the creation of a new office, the Deputy Under Secretary, to overview the laboratories; and such things as modifying the roles of the Operations Offices, and permitting the laboratories to undertake a greater quantity of work for others.

As I said earlier, we believe the Secretary will review this in the near future, and we will act according to his guidance on this.

I would like to close with a couple of quotes which also note that there are some important things that should be done with regard to National Laboratories. First, to insure that governmental research and development establishments are assigned significant and challenging work. Also to simplify management controls, eliminate unnecessary echelons of review and supervision and give to laboratory directors more authority to command resources and make administrative decisions. The second quote is that in order to make more effective use of the technical and management capabilities in the field, we should increase the delegation of program execution authority to the field and assign specific mission responsibilities to laboratories and operations offices.

Now, the interesting thing about these two quotes is that they did not come from the ERAB report. The first one came from the Bell report to the President in April 1962 through the President. The second one was done in December 1975, and that was the report to the Field and Laboratory Utilization Group that was convened at the beginning of ERDA.

So you see that some of the concerns as expressed by the ERAB report are not in a sense new. In fact the recommendations of the sixties and seventies are very consistent with what ERAB has concluded. I think these quotes call attention to the fact that it is appropriate to periodically review what you are doing, how you are doing it; and to remind yourself of how important these national facilities are, and to see to it that they are managed appropriately and well.

With that I will close and thank you. I am prepared to answer any questions.

[The prepared statement of Mr. Trivelpiece follows:]

# TESTIMONY
OF
ALVIN W. TRIVELPIECE
DIRECTOR
OFFICE OF ENERGY RESEARCH

BEFORE THE
SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
AND
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
RAYBURN HOUSE OFFICE BUILDING
DECEMBER 2, 1982

DRAFT: 11-29-82

## Introduction

Mr. and Madam Chairman and Members of the Subcommittees, I am pleased to appear before you today to discuss the Report of the Energy Research Advisory Board on the Department of Energy's major multiprogram laboratories. After receiving the report in September, the Deputy Secretary undertook a broad Headquarters and Field review of its content and recommendations. I plan to share the general results of that review with you today.

As you know, Secretary Hodel was appointed on November 5, 1982. He plans to review the ERAB report carefully. He will make his own determinations on each of the recommendations. My testimony today, (which summarizes views from Headquarters program Assistant Secretaries, Operations Office Managers and Laboratory Directors) will be useful input to Secretary Hodel's overall review.

In order to put our reactions to ERAB's Report in context, I will first summarize the current management status of the laboratories. I will then comment on ERAB's recommendations, focusing primarily on: (1) those that we are implementing or could implement without delay; and (2) those that the reviewers believe will require outside assistance to implement, or some further study.

The ERAB study is excellent. I personally believe it provides a solid basis for implementing a number of recommendations that will significantly benefit the future of the Department's multiprogram laboratories.

## Background

### Reasons for Request of ERAB Study

On September 29, 1981, the Deputy Secretary charged the Energy Research Advisory Board (ERAB) with undertaking a comprehensive study to help shape the future of the Department's multiprogram laboratories. His request reflected the fact that we take seriously both our programmatic and institutional responsibilities for the major multiprogram laboratories. The Department considers these laboratories to be a national resource. In a period of increasingly austere budgets, he was concerned about the possible erosion of the laboratories' scientific and technical strength and the impact on their ability to continue to meet the Nation's long-range energy research and development needs. In addition, the laboratories had changed during the transition from the Atomic Energy Commission to the Energy Research and Development Administration and during the early years of DOE stewardship. Some of their roles had, in fact, become significantly broadened and much less focused. In light of the new Administration's R&D policies, a review of their technological capabilities, missions, and roles seemed essential.

### Current Management Status

We are committed to maintaining the laboratories as a strong and viable national R&D resource that is essential to assuring our scientific, economic and security positions. The major multiprogram laboratories form the backbone of the Department's research, development, and engineering capabilities. Their efforts range from the most fundamental research programs in the physical and life sciences to the most advanced goal-oriented design and development programs in nuclear reactors and nuclear weapons. The laboratories consist of an unusual diversity of scientific and technical resources, manpower and facilities that represent national assets of enormous importance (Attachment 1).

Today, we pay special attention to the management and well-being of the national multiprogram laboratories. We do so in the context of all the field capabilities at our disposal, including important single program facilities. The current reporting relationship of the laboratories is based on the principle that the Director of Energy Research or the Assistant Secretary with the major amount of program activities at the laboratory should be responsible for the overall health and management of the laboratory as an institution. Our vested interest in maintaining the capability of the institution to carry out current and future programs is a strong incentive for ensuring effective management.

As directed by Congress, my office, in addition to energy research programs, has statutory responsibility to advise the Secretary on the overall well-being and management of the DOE nonweapons laboratories. I act as the agent for the Under Secretary in coordinating DOE-wide laboratory management processes, such as institutional planning. We have made significant progress in the past two years. The Under Secretary has implemented policies and procedures that should help us make more effective use of the laboratories in meeting our R&D objectives for the future. These include a systematic laboratory appraisal process and an improved institutional planning process.

The institutional planning process is a primary management tool for Headquarters overview of the direction and development of the multiprogram national laboratories. The importance of institutional planning is that it focuses on the role, well-being and future development of each laboratory as an entity, as well as part of the entire laboratory complex. The institutional plans of the major laboratories are reviewed at the Under Secretary's level. In 1982 the Under Secretary's strategic guidance to the laboratories contained a generic mission and goals statement for the laboratories, a list of the responsibilities of both field and Headquarters, and guidance on placing appropriate work at the laboratories. (Attachment 2)

Decisions on funding work at the major multiprogram laboratories must be made in the context of the capabilities of industry, universities and the laboratories, as well as existing legal and policy requirements. Equally important, such funding decisions must reflect the necessary changes in R&D emphasis from the previous Administration and be consistent with President Reagan's overall effort to improve the Nation's economy.

Among the strategic guidance materials forwarded to the laboratories this year as part of the institutional planning process was a summary of the Administration's R&D policy. The Government has a very important role in directly supporting or performing R&D where there is a substantial prospect of significant national economic gain, but where the private sector is unlikely to invest adequately because the potential gains are too remote or speculative. Thus, the Government supports basic research across all scientific disciplines. The major participants in this type of DOE research are universities and the laboratories. In applied research and technology development the Government limits its activities primarily to technologies, such as fusion power and the breeder reactor, which require a long period of initial development and where both the risk and potential payoff are high. Industrial contractors and the laboratories are the major participants in this area. The laboratories are the predominant performers when the work requires the use of resources over a long period of time, a fast start up, or special multidisciplinary expertise. Near term applications research and commercialization are considered to be the responsibility of the private sector.

The past Administration significantly broadened the role of the Government and enormously increased Federal spending on R&D. The transition from these policies is a difficult process. Notwithstanding DOE efforts to control laboratory growth during the late 1970's, the proposed FY 1983 budget reductions had a significant impact on the laboratories. Although the impact was primarily on near-term applications, some of the laboratory readjustments are painful. When compared to the end of FY 1982, the overall funding levels in nondefense work are about 10% below the FY 1980 levels. Staff reductions at the non-weapons, multiprogram laboratories ranged from 10-20%. However, I believe we are now back on the right track, without damaging the laboratories' core strengths and with the necessary scientific teams intact. This is a very important consideration since such scientific teams take many years to develop.

As you know from your discussions with laboratory directors, the laboratories are managed as single entities. Their scientific staffs are not simply the sum of the given programs funded during a single fiscal year. Primarily the laboratories hire and train scientists and engineers, not narrow project specialists. Thus, stable funding levels and early funding guidance are important to effective laboratory management. Stability and continuity consistent with the new R&D policies should now characterize our activities. The importance of such stability is a major theme of the ERAB Report.

## Comments on ERAB Panel Recommendations

### The Appropriate Roles and Missions of the Laboratories Vis-a-Vis Universities and Industry

I agree with ERAB's summary of the roles and missions of the laboratories and consider them consistent with our current guidance. In addition, the report provides a valuable perspective of the laboratories as a national asset. The Report should be quite helpful in clarifying their relationships with the other energy R&D performers in carrying out the Federal role in R&D. I believe a major overall objective of the Department is to make the most effective possible use of our national laboratories. I also believe we should continue to rely on our major laboratories to carry out important responsibilities in all of the primary and support mission areas described in the ERAB Report.

Although laboratory roles and missions are specific, they are not static. They have evolved over the past 30 years or more. There are examples in the past when changing national needs required the laboratories to make major changes in their R&D activities. They have done this in a way that compliments the foresight of our predecessors in establishing the management and operating contract concept. We expect the current traumatic but necessary realignment to be accomplished without major loss of quality.

The question of quality is one that is and will remain foremost in our decisions concerning the future roles of laboratories, universities, and industry. We do not budget on a level-of-effort basis nor do we simply take a project-by-project approach to R&D. Instead the laboratories carry out major program activities for the Department. The challenge to the multi-program laboratories is to refocus their attention on their traditional areas of expertise in nuclear weapons, basic research, and long range, high technology programs. At the same time, as recommended by ERAB, they must also continue to cooperate and pursue close relationships with universities and industry.

Thus the Administration's policies should be viewed as challenges, not simply restrictions, in determining laboratory roles. A major tenet of the R&D policy is to rely on the free market for solutions to many of our near-term energy problems. It also includes a significant commitment to continued Federal support oriented toward long-term, high-risk and potentially high-payoff research, such as that being conducted at the national laboratories. Now that the readjustment to the new policies and R&D roles has been accomplished, I believe we can concentrate on positive initiatives regarding the laboratories, including improvements in existing policies and procedures recommended by ERAB.

## The Scientific and Technological Capabilities of the Laboratories

Based on my experience, I agree with ERAB's overall evaluation of the scientific and technological capabilities of the laboratories. Although the ERAB Panel was not able to assess systematically all of the core efforts of the major laboratories, they made several visits and received briefings on special studies in this area. They found the laboratories scientific and technological capabilities impressive and laboratory leadership to be of high quality.

The ERAB Panel had an opportunity to review the extensive and systematic, in-depth evaluation of the Basic Energy Sciences program by the Office of Energy Research. The evaluation consisted of a sample of over 100 randomly selected projects whose research results were reviewed by panels of specialists in the research disciplines. It included almost 200 technical expert reviewers from industry, universities, laboratories and others in order to ensure reasonably objective comparisons could be made between laboratories and universities carrying out similar efforts. The statistically analyzed results of the study show laboratory performance compares very favorably with university performance in all areas of physical, chemical, biological, and engineering sciences. These disciplines, while small in terms of percentage of overall DOE funding, are representative of much of the research and development capabilities of the laboratories (Attachment 3).

The ERAB Panel recommendations concerning the capabilities of the laboratories focus on ways of ensuring continuing effective laboratory management and program execution. I believe the first recommendation in this category could have considerable merit, i.e., to urge the Office of Management and Budget to support rolling two-year appropriations by Congress for research and development with carry-over funding to stabilize Department and laboratory planning and program execution. DOE Staff is already reviewing the merits of two-year appropriations for all DOE R&D programs and determining what legislation would be appropriate to recommend to Secretary Hodel for submission to OMB. Implementation of this recommendation would, of course, require Congressional action.

In addition, the staff is reviewing ERAB's complementary recommendation that the Laboratory Directors should have more flexibility, within overall budgets and broad program guidelines, to reprogram a small portion of their assigned laboratory resources. Consideration will be given to permitting the laboratories some flexibility in initiating or adapting programs in accordance with research and development opportunities as they arise. Our current controls are, of course, based on the specific guidance received from the appropriations committees. We are reviewing whether to modify our internal system to raise the levels (and thereby increase flexibility) of obligation controls and cost ceilings to the maximum possible commensurate with Congressional guidance and programmatic advantage. Any additional changes which the Department might consider would require discussions with the Congress regarding the degree to which flexibility should be allowed in the use of program funds.

ERAB has also recommended that the Department should make organizational and management changes involving establishing a high level official, such as a Deputy Undersecretary for Laboratories, and reducing the responsibilities of the Department's Field Operations Offices. The roles of the Operations Offices are not static but are constantly evolving. We believe they will continue to be a necessary management tool of the Department. As the Department's character changes, however, and consistent with the Administration's policies, Secretary Hodel may want to consider undertaking an internal management review to (1) evaluate, clarify and distinguish "management" and "intermediary" roles of Operations Offices; (2) determine the effectiveness of decentralization policy and (3) undertake an overall appraisal of the Operations Offices.

I expect Secretary Hodel will also review the existing Headquarters management processes to determine how they can be further improved or whether they should be changed. Such a review would include the role of the Office of the Under Secretary in overseeing or managing the National Laboratories. In the meantime, our efforts will concentrate on resolving identified problems within the current organizational framework.

## The Department's Policies and Procedures With Respect to the Laboratories

The variety and complexity of missions and operating styles within DOE makes it undesirable to rely on one single approach to laboratory management. Our general program management philosophy is to decentralize the execution of DOE outlay programs to the maximum practical extent. We do not, of course, apply exactly the same management style for very basic research that we require for applied projects. For most applied programs, technical management and execution of approved projects can best be carried out on a day-to-day basis in the field, with specific responsibilities delegated by Headquarters to the Operations Offices and the laboratories. While I believe we should make every effort to ensure appropriate uniformity; we also need to maintain important elements of our management flexibility and diversity.

In this category of recommendations, I am particularly glad to see ERAB's endorsement of many of our laboratory management initiatives. Some, like the institutional planning process, are well-established and have already proven their usefulness both to the laboratories and to Headquarters. We will continue to improve the process consistent with ERAB's recommendations.

Others, like the laboratory appraisal process and DOE's new patent waiver policy for work for others, are just being launched. The former is expected to provide more systematic management evaluation processes, and the latter is already providing broader opportunities for the laboratories to increase their technology transfer efforts. We will carry out the education program on the new patent policy recommended by ERAB. After some experience has been gained with our new laboratory appraisal process, we should also determine whether to seek additional appropriate outside assistance from scientific peer review panels.

There are advantages of the management and operating contract and the unique relationship that it permits between the Government and the private sector that should be preserved. In order to obtain sufficient flexibility to achieve our program objectives, we must continue to be able to tap the personnel resources of industry and the universities, to utilize some of the flexibility of the procurement structure of private organizations, and also to gain continued access to the industrial know-how and managerial expertise developed by the contractor organizations.

We recognize the gradual accretion of reporting requirements that has occurred in the past decade and our need to improve in this area to the extent possible. There is a working group already underway on this problem. Following completion of our in-house review, consideration will be given to determining whether it is desirable also to seek a non-Government reviewer to conduct an audit of the impact of the paperwork requirements on the field.

## The Effectiveness of the Department's Use of the Laboratories in Meeting Its Energy Objectives

I believe ERAB has made some very useful recommendations aimed at improving the effectiveness of the Department's use of the laboratories in meeting our energy objectives. We agree the laboratory directors should more effectively participate in the Department's R&D policy process.

This occurs informally through frequent meetings and communications between laboratory directors, and the Office of Energy Research and program Assistant Secretaries; as well as through direct participation at program levels. Appropriate laboratory input will continue to be ensured through quarterly meetings I have begun holding with the laboratory directors. We will consider additional formal and informal mechanisms for ensuring appropriate participation in the future.

In related areas, ERAB recommended continuation or more vigorous implementation of lead mission assignments to the laboratories. They also suggested special attention should be given to optimal productive use of sophisticated equipment and facilities. We plan to continue our efforts in these areas and to review them with an aim toward improving our effectiveness. The program Assistant Secretaries are also reviewing their needs to determine the advisability of seeking appropriate additional customer advice concerning their programs, as recommended by ERAB.

I support ERAB's recommendation to permit the laboratories to use a small percentage of their R&D budget for idea development, exploration studies and general efforts to upgrade and acquire skills in new technology areas. We have reviewed our current process which varies by laboratory, and will determine what steps are advisable toward establishing a uniform policy.

Potentially, the most useful recommendations in the ERAB report, in my opinion, are in the area calling for better use of the complementary capabilities of the university, industry, and laboratory sectors. This has been a major initiative as part of the institutional planning process for the past two years. We have made much progress and the ERAB recommendations offer opportunities for considering further improvements in several areas.

It has long been a policy of DOE and its predecessor agencies to foster laboratory interactions with the private sector. During the early years of the AEC, the focus was on close relationships in building the nuclear industry. In my view, the transfer of light water reactor and nuclear medicine research applications to industry were two of the most important technology transfer successes of modern times. More recently, the laboratories have become involved in technology transfer activities in almost all of the Department's program areas. The ERAB report presents a good summary of DOE activities ranging from workshops, and research collaboration, to subcontracting from the laboratories to industry. (Attachment 4)

Through the national laboratories, the Department also makes available many of its facilities and scientific research instrumentation to both university and industry researchers. The Stanford Linear Accelerator Center and Fermi National Accelerator Laboratory have long been models of effective collaboration in high energy physics research. The Combustion Research Facility at Sandia and the National Synchrotron Light Source at Brookhaven National Laboratory are two of the newest and most significant examples of our efforts in basic energy sciences in providing important scientific facilities to universities and industry. (Attachment 5)

As you know, the ERAB report compliments the laboratories' efforts in this area, as well as the Department's preliminary efforts to implement the Stevenson-Wydler Act. We have undertaken a review of remaining institutional and doctrinal barriers to effective technology transfer. We also appreciate the Panel's support of our recent effort to liberalize DOE's patent policy in connection with laboratory work for others. We are in the process of extending the class waiver to user facilities.

The ERAB report urges DOE to permit and encourage joint ventures with industry and to relax further its policy constraints and restrictions on laboratory work for others in order for the laboratories to make an even greater contribution to our national technological interests. We are reviewing current barriers and constraints to joint ventures. We are also carefully considering all of the recommendations of ERAB aimed at permitting even further laboratory reimbursable work for other agencies and not-for-profit organizations. This will be a complicated and challenging issue for the Secretary to consider.

Significant policy revisions would require OMB and other approvals outside DOE. In my view, our aim will be to accomplish our objective in a way that will ensure that the scientific and technical capabilities of the laboratories will be able to contribute even more significantly than they have in the past to meeting our Nation's needs to increase productivity, innovation and competitiveness in the international arena. A key to our policy reconsideration will be to ensure that in doing so, the laboratories work in collaboration with, but not in competition with private industry.

That concludes my testimony. I will be glad to respond to any questions, or to elaborate on the information on the laboratories which I have enclosed for the record.

Attachments to Alvin W. Trivelpiece's Testimony for 12/2/82
Hearings before House Committee on Science and Technology

Attachment 1
Summaries on Multiprogram Laboratories and Organization Chart

Attachment 2
Guy W. Fiske Guidance Memo on Institutional Planning, May 5, 1982, and Additional Data on Institutional Planning Process

Attachment 3
Summary from Volume I, Technical Report, "An Assessment of Basic Energy Sciences Program," March 1982

Attachment 4
Summary from DOE Biennial Report - Summary of Technology Transfer Activities (Oct 1, 1980 - Sept 30, 1982)

Multiprogram Laboratory Accomplishments, April 6, 1982

Technology Transfer Order, DOE 5800.1, June 15, 1982

Attachment 5
Summary on DOE User Facilities with Partial List of Facilities, November, 1982

Short Summary on Combustion Research Facility and National Synchrotron Light Source

September, 1982

## AMES LABORATORY
Ames, Iowa

The Ames Laboratory conducts basic research in materials and chemical sciences relying upon existing capabilities for preparing high purity metals, alloys, compounds and single crystals, and conducts materials related research and development in areas such as nondestructive testing of materials. Smaller but unique and vigorous capabilities are maintained in high energy physics, nuclear physics, applied mathematics, coal preparation science, and solar technology. The laboratory enjoys extensive cooperation with Iowa State University through year-round faculty appointment, graduate student training, and facilities sharing programs.

An effective summer research participation program for undergraduate students and faculty members (primarily from non-local institutions) is maintained by the laboratory to the mutual benefit of it, the participants, and their institutions. The Ames Laboratory actively disseminates the results of its work throughout the scientific and technological communities by the distribution of technical publications, the giving of invited presentations on technologically important topics, the consulting activities of laboratory staff members, the conduct of cooperative projects with industrial and other governmental concerns, and participation in the Federal Laboratory Consortium.

| Statistics: | FY 1982 (Estimated) |
|---|---|
| DOE Operating Budget Costs: | $15 M |
| Staff (Full-Time Equivalent): | 410 |
| Capital Investment (Plant and Equipment): | $34 M |
| Number of Acres: | 56 |

Operating Contractor: Iowa State University

Responsible Operations Office: Chicago Operations Office

Principal Program Activities (FY 1982 Estimated):

- Materials Sciences (43%)
- Chemical Sciences (19%)
- Fossil Energy (8%)
- Biological and Environmental Research (6%)
- High Energy Physics (5%)
- Nuclear Physics & Nuclear Sciences (2%)
- Engineering, Mathematical & Geosciences (2%)
- University Research Support (2%)
- Miscellaneous DOE Programs (5%)
- Work for others (8%)
  - Nuclear Regulatory Commission (2%)
  - Department of Defense (4%)

Major User Facilities

Materials Preparation Center
Coal Treatment Plant

Attachment 1

## ARGONNE NATIONAL LABORATORY[1]

Argonne, Illinois

The Argonne National Laboratory (ANL) provides advanced nuclear technology research and development support to the breeder reactor and other fission reactor programs, and maintains a substantial, diversified capability in physical and biological sciences. Efforts in the fossil area center on advanced process development, the materials technology, and instrumentation and controls systems engineering. In basic research, the largest effort is in the area of general materials studies. High energy physics and nuclear physics will continue to be a significant role. The consequences of the utilization of particular energy technologies are addressed through studies of health-related problems and the environment.

The laboratory has a program to work closely with university professors on sabbatical leaves and sponsors a variety of programs providing opportunities for students through student-laboratory staff interaction. Argonne is engaging in a number of activities aimed at improving industrial interactions, including involvement in the joint IRI/National Laboratory Task Force, as well as others.

| Statistics: | FY 1982 (Estimated) |
|---|---|
| DOE Operating Budget Costs: | $210 M |
| Staff (Full-Time Equivalent): | 4,300 |
| Capital Investment (Plant and Equipment): | $545 M |
| Number of Acres: | 2,245 |

Operating Contractor: The University of Chicago in cooperation with the Argonne Universities Association

Responsible Operations Office: Chicago Operations Office

Principal Program Activities:

- Nuclear Energy (39%)
- Basic Energy Sciences (17%)
- Conservation and Renewable Energy (7%)
- Biology (6%)
- Fossil Energy (6%)
- High Energy Physics (3%)
- Nuclear Physics (3%)
- Environmental Protection, Safety, and Emergency Preparedness (2%)
- Fusion (2%)
- Miscellaneous DOE Programs (4%)
- Work for Others (11%)
    - Nuclear Regulatory Commission (5%)

Major Active Facilities:

- Experimental Breeder Reactor II
- Hot Fuels Examination Facilities
- TREAT Reactor
- Zero Power Plutonium Reactor

Major User Facilities:

- Intensed Pulsed Neutron Source I
- Facility for High Resolution Atomic Spectroscopy
- Argonne Tandem Linac Accelerator
- High Voltage Electron Microscope

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[1] Includes Argonne National Laboratory West, Idaho.

BROOKHAVEN NATIONAL LABORATORY
Upton, New York

The Brookhaven National Laboratory (BNL) conceives, develops, constructs, and operates complex large research facilities which are used to study fundamental properties of matter and are shared with university and industrial scientific communities (e.g., the National Synchrotron Light Source and the Alternating Gradient Synchrotron). The laboratory conducts basic and applied research in technology base areas, in support of research facilities, and to discover important new directions for research. Major disciplinary strength is found in the areas of high energy, nuclear and solid state physics, chemistry, and biology. Biological and medical programs include studies of the effects of radiation and of chemical substances involved in the production and use of energy. Other research programs include meteorological dispersion, atmospheric chemistry, pulmonary physiology, and inhalation toxicology.

The facilities listed below give the laboratory a unique position in the breadth of sophisticated facilities available to all areas of the physical and biological sciences. Over 1,000 faculty and 160 students have guest appointments enabling them to carry out research at BNL facilities. In addition, there are five different programs which provide 150 students with a variety of training opportunities. The National Synchrotron Light Source is greatly increasing the number of faculty and students carrying out research programs at the laboratory. This facility will also be used extensively by industrial scientists; presently, nine of the 29 initial beam lines at the facility are partially or completely supported by the industrial community.

| Statistics: | FY 1982 (Estimated) |
|---|---|
| DOE Operating Budget Costs: | $128 M |
| Staff (Full-Time Equivalent): | 3,250 |
| Capital Investment (Plant and Equipment): | $469 M |
| Number of Acres: | 5,265 |

Operating Contractor: Associated Universities, Inc.

Responsible Operations Office: Chicago Operations Office

Principal Program Activities (FY 1982 Estimated):

High Energy Physics (32%)
Basic Energy Sciences (20%)
Environmental Research and Development (6%)
Life Sciences Research and Nuclear Applications (6%)
Nuclear Physics (3%)
Miscellaneous DOE Programs (10%)
Work For Others (23%)
    Nuclear Regulatory Commission (11%)

Major Active Facilities:

Alternating Gradient Synchrotron
High Flux Beam Reactor
Tandem van de Graaff
National Synchrotron Light Source

Major User Facilities: 1/

60-Inch Cyclotron
Scanning Transmission Electron Microscope

Positron Emission Transaxial Tomography Facility

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1/ In addition to facilities listed under Major Active Facilities column.

## LAWRENCE BERKELEY LABORATORY
Berkeley, California

The Lawrence Berkeley Laboratory (LBL) conceives, develops, constructs and operates complex large research facilities which are shared with university and industrial scientific communities (e.g., Bevalac and Super HILAC). The laboratory capitalizes on its co-location with the University of California to provide a broad range and flexible pool of scientific talent for research and advanced development; with major research programs in high-energy physics, nuclear physics, basic energy sciences, conservation and solar energy, coal research, inertial confinement fusion, geochemistry, computer science and mathematics. LBL has a role in the training of the next generation of scientists and engineers for careers in advanced energy research and technology.

Over 500 resident graduate students conduct thesis research at the laboratory and many more use its facilities or perform collaborative research. Participation in energy research programs provides these students with skills in high demand by energy industries. The flow of Ph. D's to industry is one of many forms of technology transfer that allows LBL to maintain close and supportive relationships with industry.

| Statistics: | FY 1982 (Estimated) |
|---|---|
| DOE Operating Budget Costs: | $91 M |
| Staff (Full-Time Equivalent): | 2,643 |
| Capital Investment (Plant and Equipment): | $195 M |
| Number of Acres: | 70 1/ |

**Operating Contractor:** The Regents of the University of California

**Responsible Operations Office:** San Francisco Operations Office

**Principal Program Activities (FY 1982 Estimated):**

Energy Research (54%)
Conservation & Renewable Energy (16%)
Fossil Energy (2%)
Miscellaneous DOE Programs (11%)

Work for Others (17%)
    Nuclear Regulatory Commission (4%)
    Department of Defense (2%)

**Major Active and User Facilities:**

Bevatron
SuperHILAC
Center for Electron Microscopy
Tritium Labeling Facility
88 Inch Cyclotron

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1/ Leased to the Government.

## LAWRENCE LIVERMORE NATIONAL LABORATORY
Livermore, California

The mission of the Lawrence Livermore National Laboratory (LLNL) is to function as an integral scientific and technical element of the nation's nuclear weapons program. As appropriate, the mission includes the sharing or transferring of technology to the public and private sectors. In support of this mission, its primary role is to provide the nuclear design and associated research, development, and test activities required for all phases of a nuclear weapon life cycle from concept development, through stockpile maintenance and retirement. A corollary role is the application of its capabilities in other national problems in areas where its specific mix of skills and facilities can make significant or unique contributions. The activities undertaken are based on the need to maintain pre-eminence in that broad range of scientific and technical endeavor required for its defense-related tasks, and by the need to make that most efficient use, in this national interest, of the major resource that these skills and capabilities represent. Within these constaints, the laboratory has developed several areas of long-term commitments; inertial fusion, magnetic fusion, biomedical and environmental research, isotope separation, and a wide range of interrelated fundamental and applied research and development activities.

| Statistics: | FY 1982 (Estimated) |
|---|---|
| DOE Operating Budget Costs: | $421 M |
| Staff (Full-Time Equivalent): | 7,380 |
| Capital Investment (Plant and Equipment): | $459 M |
| Number of Acres: | 631 |

Operating Contractor: University of California

Responsible Operations Office: San Francisco Operations Office

Principal Program Activities (FY 1982 Estimated):

Defense Programs (47%)
Magnetic Fusion (10%)
Laser Fusion Energy (11%)
Isotope Separation (9%)
Energy Programs (4%)
Biomedical/Environmental (3%)
Miscellaneous DOE Programs (4%)
Work for Others (12%)
    Department of Defense (8%)
    Nuclear Regulatory Commission (2%)

Major Active Facilities:

Novette Experiment
Nova Laser Fusion Facility (in progress)
100 MeV Accelerator Facility
National Defense Supported Livermore Computer Center
Gaseous and Metallurgical Facility
  (Plutonium & Tritium)
Magnetic Fusion Energy Facility
14 MeV Rotating Target Neutron Source
Mirror Fusion Test Facility (MFTF-B) (in progress)
Tandem Mirror Experiment (TMX)
National Magnetic Fusion Energy Computation Center
Fusion Target Development Facility
High Explosive Flash Radiograph Facility
Weapons Materials R&D Facility (in progress)
Management Support Center - Core I
High Explosive Application Facility (in progress)
Special Isotope Separation Facility (in progress)
Advanced Test Accelerator Facility (in progress)
Large Optics Diamond Turning Facility
High Field Test Facility

## LOS ALAMOS NATIONAL LABORATORY
Los Alamos, New Mexico

The Los Alamos National Laboratory's (LANL) primary mission is the application of science and technology to problems of national security, that is, to the maintenance of a strong defense, the fulfillment of arms control commitments, and the guarantee of a secure energy supply for the future. In carrying out this mission, the laboratory serves as a liaison between research in academia and industry and complements the activities of both. Major programs include developing nuclear warheads, designing and testing advanced technology concepts, and maintaining an innovative weapons design program. In nuclear fission, programs include separating isotopes of uranium by laser induction, testing advanced reactor fuel elements, modeling reactor accident results for the Nuclear Regulatory Commission, evaluating biomedical consequences of nuclear energy production, and developing effective nuclear waste disposal methods. In nuclear fusion, programs include magnetically confined plasma devices (especially high-beta devices), laser-induced fusion, and safe handling techniques for large quantities of tritium. Other programs include nonnuclear energy, basic energy science, and technology utilization.

| Statistics: | FY 1982 (Estimated) |
|---|---|
| DOE Operating Budget Costs: | $440 M |
| Staff (Full-Time Equivalent): | 7,178 |
| Capital Investment (Plant and Equipment): | $369 M [1/] |
| Number of Acres: | 27,800 |

Operating Contractor: University of California

Responsible Operations Office: Albuquerque Operations Office

Principal Program Activities:

Weapons (45%)
Nuclear Physics (8%)
Magnetic Fusion (4%)
Advanced Isotope Separation Technology (4%)
Breeder (4%)
Safeguards (2%)
Verification & Control (2%)

Nuclear Materials Production (3%)
Miscellaneous DOE Programs (13%)
Other DOE (5%)
Work for Others (10%)
  Nuclear Regulatory Commission (3%)
  Department of Defense (5%)

Major Active Facilities:

800 Million Electron-Volt Linear Proton Accelerator (LAMPF)
Weapons Neutron Research Facility
Stable Isotopes Production Facility
20 Terrawatt $CO_2$ Gas Laser Facility
8 Megawatt Nuclear Reactor
Plutonium Research Facility
Plutonium Heat Sources Fuel Production Facility
National Security Resources and Studies Center

Major User Facilities:

Clinton P. Anderson Meson Physics Facility (LAMPF)

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[1/] Current Book Value (excludes construction work in progress).

## OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee

The Oak Ridge National Laboratory (ORNL) primarily supports the fission nuclear fuel cycle and magnetic fusion energy development (advanced toroidal devices, such as Tokamak and Elmo Bumpy Torus) through scientific research and technology; identifies and solves generic research problems in energy technologies such as materials, separation techniques, chemical processes and biotechnology; and is the major national source of production of stable and radioactive isotopes. Energy technology development at ORNL also includes other important efforts in residential and commercial energy conservation, renewable energy sources, and coal conversion and utilization.

ORNL expends special effort to involve industry in its programs and to encourage cooperative uses of facilities, both formally in users' groups and informally through professional contacts and participation. Similarly, the Laboratory provides universities with ready access to major research facilities, state-of-the-art research capabilities, training facilities for faculty and students, and an opportunity for collaborative research in areas where these resources are not available to universities.

| **Statistics:** | **FY 1982 (Estimated)** |
|---|---|
| DOE Operating Budget Costs: | $265 M |
| Staff (Full-Time Equivalent): | 4,700 |
| Capital Investment (Plant and Equipment): | $250 M |
| Number of Acres: | 10,270 |

**Operating Contractor:** Union Carbide Corporation, Nuclear Division

**Responsible Operations Office:** Oak Ridge Operations Office

**Principal Program Activities:**

Fission Energy Development (20%)
Basic Physical Science (15%)
Fusion Energy (16%)
Conservation and Renewable Energy (11%)
Biomedical and Environmental Sciences (9%)
Fossil Energy (5%)
Miscellaneous DOE Programs (5%)
Work for Others (19%)
    Nuclear Regulatory Commission (7%)
    Department of Defense (1%)

**Major Active Facilities:**

Isotopes Separation Facility
High Flux Isotope Reactor
Electron Linear Accelerator
Transuranium Processing Plant
Oak Ridge Research Reactor
High Level Radiochemical Laboratory
Materials Processing Laboratory
High Radiation Level Examination Laboratory
Environmental Sciences Laboratory

**Major User Facilities:**

Holifield Heavy Ion Research Facility
EN-Tandem Accelerator
Oak Ridge Electron Linear Accelerator (ORELA)
Neutron Scattering Facility
National Center for Small-Angle Scattering Research
Ion-Solid Interactions Laboratory
Shared Research Equipment Program (SHaRE)

## PACIFIC NORTHWEST LABORATORY
Richland, Washington

The mission of the Pacific Northwest Laboratory (PNL) is the advancement and use of multi-disciplined scientific and engineering technology for national security and the nation's energy needs. In accomplishing this mission, high priority is given to safe and reliable nuclear energy, and to promising new concepts and technologies for operations at Hanford. Areas of disciplinary strengths and concentration include nuclear waste process development, nuclear fuel development and evaluation, spent fuel storage and reprocessing, inhalation toxicology, bioelectromagnetics, biology, ecology, atomspheric sciences, corrosion chemistry, biomass research, nondestructive testing and evaluation, materials characterization and research, chemical engineering, health physics technology and energy economics and policy analyses.

The laboratory provides a core capability for effectively utilizing the strengths of the universities and the private sector and has traditionally developed and maintained strong ties with the academic community. That resource is utilized through cooperative exploratory research efforts to accelerate application of new ideas, scientific research support to PNL efforts on team assignments, and exchange of staff and student research. Industry and utilities participate with PNL staff in efforts to develop advanced technology, to improve existing instruments or develop new ones, and to investigate and demonstrate energy conservation and conversion techniques.

| Statistics: | FY 1982 (Estimated) |
|---|---|
| DOE Operating Budget Costs: | $98 M |
| Staff (Full-Time Equivalent): | 1,975 |
| Capital Investment (Plant and Equipment): | $65 M |
| Number of Acres: | Not Applicable [1] |

**Operating Contractor:** Battelle Memorial Institute

**Responsible Operations Office:** Richland Operations Office

**Principal Program Activities (FY 1982 Estimated):**

Fission (25%)
Defense (17%)
Life Sciences (16%)
Conservation (7%)
Renewable (7%)
Basic Sciences (5%)
Miscellaneous DOE Programs (3%)

Work for Others (20%)
    Nuclear Regulatory Commission (15%)
    Department of Defense (3%)

**Major Active Facilities:**

Two Life Science Laboratories
Marine Research Laboratory
Meteorological Center
Nuclear Waste Vitrification Laboratory

Materials Reliability Center
Steam Generator Examination Facility
Biomass Experimental Unit
Geophysical and Astronomical Observatory
National Environmental Research Park

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[1] PNL facilities are in an area shared with Hanford Engineering Development Laboratory and UNC Nuclear Industries.

## SANDIA NATIONAL LABORATORIES

Albuquerque, New Mexico; Livermore, California; Tonopah, Nevada

Sandia National Laboratories' principal mission has been and remains research, development, and engineering of nuclear weapon systems, except for the nuclear explosive. The result of this effort is the existence of a national stockpile of nuclear weapons that are safe, secure, reliable, under strict control, and operationally ready. Sandia is also responsible for energy programs in fossil, solar, fission, and basic energy sciences. Its strength lies in its ability to conduct large, interdisciplinary engineering projects that are both technologically "risky" and sophisticated.

Fundamental understanding and technological development are melded to create an environment conducive to generating new products and processes that are unlikely to be produced in either university or industrial laboratories. These new technologies are transmitted to the private sector through journals, workshops, and other information-transfer mechanisms, and significantly contribute to the nation's scientific and economic prosperity.

| Statistics: | FY 1982 (Estimated) |
|---|---|
| DOE Operating Budget Costs: | $540 M |
| Staff (Full-Time Equivalent): | 7,950 |
| Capital Investment (Plant and Equipment): | $260 M 1/ |
| Number of Acres: | 3,140 (Albuquerque)<br>185 (Livermore) |

Operating Contractor: Western Electric Company

Responsible Operations Office: Albuquerque Operations Office

Principal Program Activities:

- Weapons (59%)
- Solar (4%)
- Verification and Control (3%)
- Fossil Energy (3%)
- Security and Safeguards (3%)
- Basic Energy Sciences (2%)
- Miscellaneous DOE Programs (7%)
- Other DOE (3%)
- Work for Others (16%)
  - Department of Defense (10%)
  - Nuclear Regulatory Commission (5%)

Major Active Facilities:

- Particle Beam Fusion Facility
- Nuclear Safeguards and Security Facility
- Combustion Research Facility
- 5-megawatt Solar Central Power Test Facility
- Center for Radiation-hardened Microelectronics
- Tonopah Test Range

Major User Facilities:

- Combustion Research Facility

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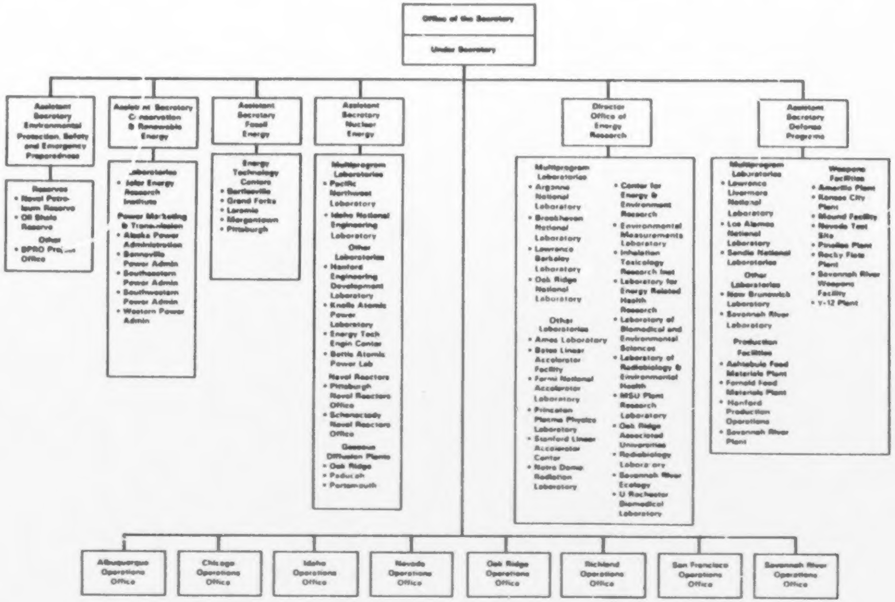
1/ Current Book Value (Excludes Construction Work in Progress).

# DOE Field Facilities Reporting Organization


Office of the Secretary
Under Secretary
Assistant Secretary Environmental Protection, Safety and Emergency Preparedness
Reserves
• Naval Petroleum Reserve
• Oil Shale Reserve
Other
• SPRO Project Office
Assistant Secretary Conservation & Renewable Energy
Laboratories
• Solar Energy Research Institute
Power Marketing & Transmission
• Alaska Power Administration
• Bonneville Power Admin
• Southeastern Power Admin
• Southwestern Power Admin
• Western Power Admin
Assistant Secretary Fossil Energy
Energy Technology Centers
• Bartlesville
• Grand Forks
• Laramie
• Morgantown
• Pittsburgh
Assistant Secretary Nuclear Energy
Multiprogram Laboratories
• Pacific Northwest Laboratory
• Idaho National Engineering Laboratory
Other Laboratories
• Hanford Engineering Development Laboratory
• Knolls Atomic Power Laboratory
• Energy Tech Engin Center
• Bettis Atomic Power Lab
Naval Reactors
• Pittsburgh Naval Reactors Office
• Schenectady Naval Reactors Office
Gaseous Diffusion Plants
• Oak Ridge
• Paducah
• Portsmouth
Director Office of Energy Research
Multiprogram Laboratories
• Argonne National Laboratory
• Brookhaven National Laboratory
• Lawrence Berkeley Laboratory
• Oak Ridge National Laboratory
Other Laboratories
• Ames Laboratory
• Bates Linear Accelerator Facility
• Fermi National Accelerator Laboratory
• Princeton Plasma Physics Laboratory
• Stanford Linear Accelerator Center
• Notre Dame Radiation Laboratory
• Center for Energy & Environment Research
• Environmental Measurements Laboratory
• Inhalation Toxicology Research Inst
• Laboratory for Energy Related Health Research
• Laboratory of Biomedical and Environmental Sciences
• Laboratory of Radiobiology & Environmental Health
• MSU Plant Research Laboratory
• Oak Ridge Associated Universities
• Radiobiology Laboratory
• Savannah River Ecology
• U Rochester Biomedical Laboratory
Assistant Secretary Defense Programs
Multiprogram Laboratories
• Lawrence Livermore National Laboratory
• Los Alamos National Laboratory
• Sandia National Laboratories
Other Laboratories
• New Brunswick Laboratory
• Savannah River Laboratory
Production Facilities
• Ashtabula Feed Materials Plant
• Fernald Feed Materials Plant
• Hanford Production Operations
• Savannah River Plant
Weapons Facilities
• Amarillo Plant
• Kansas City Plant
• Mound Facility
• Nevada Test Site
• Pinellas Plant
• Rocky Flats Plant
• Savannah River Weapons Facility
• Y-12 Plant
Albuquerque Operations Office
Chicago Operations Office
Idaho Operations Office
Nevada Operations Office
Oak Ridge Operations Office
Richland Operations Office
San Francisco Operations Office
Savannah River Operations Office

Attachment 1

ATTACHMENT 1

## DOE FACILITIES PARTICIPATING IN THE INSTITUTIONAL PLANNING PROCESS LISTED BY COGNIZANT SECRETARIAL OFFICER

Director of Energy Research:
- Ames Laboratory
- Argonne National Laboratory
- Brookhaven National Laboratory
- Lawrence Berkeley Laboratory
- Oak Ridge National Laboratory

Assistant Secretary for Defense Programs:
- Lawrence Livermore National Laboratory
- Los Alamos National Laboratory
- Sandia National Laboratories

Assistant Secretary for Nuclear Energy:
- Hanford Engineering Development Laboratory
- Idaho National Engineering Development Laboratory
- Pacific Northwest Laboratory

Assistant Secretary for Conservation and Renewable Energy:
- Solar Energy Research Institute

## THE INSTITUTIONAL PLANNING PROCESS

The institutional planning process is the management tool for Headquarters overview of the direction and development of the multiprogram national laboratories. The process results in an annually updated five-year plan. It includes the new work approval process, the work for others approval process, the lead mission assignment process, the general purpose facilities program, and the R & D laboratory technology transfer program. It integrates site development planning activities and provides a reference programmatic workload for them. The importance of institutional planning is that it focuses on the role, well-being and future development of each laboratory as a whole.

### Preliminary Data

The Preliminary Data submittal is the initial laboratory action in the annual institutional planning cycle. The Preliminary Data represent the laboratory's proposed long-term plan, submitted through the operations office, for consideration by the cognizant Secretarial Officer. The plan is an aggregation of all the laboratory program plans, adjusted by Headquarters guidance and the laboratory's estimate of realistic expectations for future funding. It is thus the laboratory's initial plan for future operations. It also serves as a vehicle for bringing the laboratory issues, new program initiatives, new lead mission assignments, and new construction initiatives to the attention of the program and cognizant Secretarial Officers.

### On-Site Review

The On-Site Review is the forum in which the Preliminary Data are formally reviewed. The review provides direct communication among the laboratory director, the operations office manager, and the cognizant Secretarial Officer. It provides a direct interchange on major issues and guidance with those program Secretarial Officers who are major users of the laboratory. In some instances, the Under Secretary, the chief operations officer for the Agency, will attend reviews and contribute to the guidance for the laboratory.

### Institutional Plan

An Institutional Plan incorporating the guidance provided by the On-Site Review is submitted to the cognizant Secretarial Officer, through the operations office. The plan is approved by the cognizant Assistant Secretarial Officer and reviewed by the Under Secretary during the fall meeting of the Field and Laboratory Coordination Council (FLCC).

### Operating Year

The operations offices have laboratory overview functions throughout the operating year. In general, these have to do with direct monitoring of laboratory operations, flow of funding from the Agency to the laboratories, and the appropriateness of new work assignments and work for others, with regard to the role established for each laboratory.

## SCHEDULE FOR FY 1983-1988 INSTITUTIONAL PLANNING PROCESS

| | |
|---|---|
| May 1982 | Under Secretary issues general guidance and call. |
| | Director of Energy Research issues general schedule and format instructions. |
| | Cognizant Secretarial Officers issue initial guidance and call to laboratories (through operations offices) for Preliminary Data. |
| June | Laboratories submit preliminary data for On-Site Reviews (operations offices review and report to Headquarters). |
| | Program Secretarial Officers review data, provide comment and recommendations to cognizant Secretarial Officers. |
| July | On-Site Reviews. |
| August | Cognizant Secretarial Officers issue specific guidance and call to laboratories (through operations offices) for institutional plans. |
| November | Laboratories submit plan (operations offices review and report to Headquarters). |
| | Program Secretarial Officers review plans, provide comments and recommendations to cognizant Secretarial Officers. |
| December | Cognizant Secretarial Officers approve plans. |
| | Under Secretary reviews approved plans at FLCC meeting. |
| | Operations offices reconcile financial plans with Institutional Plan baseline, program guidance, and laboratory resources. |
| Throughout Year | Operations offices conduct new work approval procedures and work for others approval procedures. |
| | Under Secretary resolves issues as necessary. |

## REFERENCE DOE ORDERS

| | | |
|---|---|---|
| 1130.1 | Field and Laboratory Coordination Council | 8/22/78 |
| 5650.2 | Classification of Information | 12/12/78 |
| 5600.1 | Management of the Department of Energy Weapon Program and Weapon Complex | 6/27/79 |
| 1340.1 | Management of Public Communications Publications, and Scientific, Technical, and Engineering Publications | 8/10/79 |
| 5000.1 | Institutional Planning Process | 6/25/80 |
| 4320.1 | Site Development and Facilities Utilization Planning | 4/29/81 |
| 5700.7 | Field Work Package Proposal and Authorization System | 4/29/81 |
| 4300.2 | Research and Development Work Performed for Others by Government-Owned, Contractor-Operated Facilities | 10/8/81 |
| 4330.2A | In-House Energy Management Program | 2/16/82 |
| 4330.4 | Real Property Maintenance Management | 3/25/82 |
| 5800.1 | Research and Development Laboratory Technology Transfer Program | 3/25/82 |

U.S. DEPARTMENT OF ENERGY

# memorandum

DATE: May 5, 1982

REPLY TO ATTN OF: ER-42

SUBJECT: Policy Guidance for FY 1983-1988
Multiprogram Laboratory Institutional Planning

TO: Assistant Secretaries
Director of Energy Research
Managers, Operations Offices

Institutional planning is the process by which cognizant Secretarial Officers administer their institutional responsibilities for the national multiprogram laboratories. Institutional Plans for the period FY 1983-1988 are required for the DOE laboratories listed in Attachment 1. The Director of Energy Research will coordinate the overall planning process and will issue a Department schedule and format instruction under separate cover. The operations offices will be the focal point for implementation of this process.

As has been true since the early days of the Atomic Energy Commission, it is important that the work assigned to the laboratories be appropriate to the roles of the laboratories vis-a-vis industry and universities. My guidance in this regard is contained in the generic statement of the missions and goals of multiprogram laboratories and the criteria for conduct of work at these laboratories (see Attachment 2). This guidance is based on an iterative process with the Secretarial Officers, Operations Office Managers, and Laboratory Directors. It has evolved from the institutional planning guidance of May 1, 1981, and reflects current policies. This guidance gives us a solid base from which to incorporate the constructive suggestions that are expected to result from both the Energy Research Advisory Board DOE laboratory study and the Office of Science and Technology Policy Federal laboratory study. Meanwhile, I expect all Secretarial Officers to make their work assignments to the laboratories consistent with the attached policy statements.

For your further guidance, I have also attached a summary of the respective management responsibilities of Headquarters, the operations offices, and the multiprogram laboratories. General information on the Administration's philosophies and policies affecting research and development are contained in the attached statements from the Federal Coordinating Council for Science, Engineering, and Technology and the Office of Science and Technology Policy.

Guy W. Fiske

Guy W. Fiske
Under Secretary

5 Attachments

cc:
Directors, Multiprogram
  Laboratories

Attachment 2

ATTACHMENT 2

4/9/82

# MISSIONS AND GOALS
# FOR
# DEPARTMENT OF ENERGY
# NATIONAL MULTIPROGRAM RESEARCH AND DEVELOPMENT LABORATORIES

## MISSIONS

- The Department of Energy (DOE) multiprogram laboratories exist to perform research and development at the frontiers of knowledge in the areas of nuclear weapons and other defense-related activities, nuclear and nonnuclear energy, high energy and nuclear physics, basic research, and energy-related life and environmental sciences.
- The laboratories contribute to maintaining our national security posture, in the broadest sense, including national defense and national economic strength.
- The laboratories, in cooperation with universities and industry, contribute significantly to the technology base which provides the Nation with an increased capability to foster enhanced industrial productivity and innovation.
- The laboratories' activities are an integral part of the United States' leadership position in critical areas of science and technology.

## GOALS

(Mission-direct)

- Perform research, development, engineering, and technical and production support for nuclear weapons, associated nuclear materials, and other defense-related activities.
- Perform national trust missions in high energy and nuclear physics and basic research.
- Perform research and development on nuclear energy.
- Perform research and development on long-term, high-risk, high-payoff energy technologies beyond the development horizon of the private sector.
- Be the focal point for conduct of DOE-sponsored technology base research and development.
- Construct, maintain, and operate specialized, capital intensive research facilities and provide access to users in the university and industrial research communities.

(Mission-indirect)

- Provide for and encourage the transfer of the technology developed at the laboratories to private and public sectors.
- Provide technical counsel, as assigned, on national research and development program activities.
- Contribute toward the education and training of the country's scientists and engineers within areas of technical expertise.
- Provide research and development support, as appropriate, to other government agencies, especially the Department of Defense and the Nuclear Regulatory Commission.
- Make special expertise and capabilities within the laboratories available for public and private sectors on a reimbursable basis when it does not unduly interfere with assigned mission work.
- Perform research and development in areas where industry and, where relevant, universities would have an apparent or actual conflict of interest.

ATTACHMENT 2
4/9/82

# CRITERIA FOR
# CONDUCT OF WORK AT
# DEPARTMENT OF ENERGY
# NATIONAL MULTIPROGRAM RESEARCH AND DEVELOPMENT LABORATORIES

The national multiprogram laboratories exist primarily to work on critical, high technology problems affecting our national security, energy, and economic postures. The primary criterion for placing DOE-sponsored work is the use of the best available scientific and technical capability to do the job. In general, work may be conducted by the DOE multiprogram laboratories when it involves one or more of the following:

- National security including protection and control of technology.
- Use of high scientific competence or specialized facilities available at laboratories.
- Independent assessment or verification capability not otherwise available.
- Maintenance of both scientific staff core capabilities and dedicated operation of major facilities.
- Commitment of multidisciplinary scientific staff resources or major facilities over long periods of time.
- Fast start-up or multidisciplinary approach not readily available in the private sector to meet an urgent research and development need.
- A need that is beyond the capability and interest of universities or private industries to perform.

ATTACHMENT 3

4/9/82

# MANAGEMENT RESPONSIBILITIES FOR DEPARTMENT OF ENERGY GOVERNMENT-OWNED, CONTRACTOR-OPERATED NATIONAL MULTIPROGRAM RESEARCH AND DEVELOPMENT LABORATORIES

- Headquarters:
  - Establishes policy and overall guidance for utilization of the laboratories.
  - Conducts annual institutional planning process coordinating the assignment of work to the laboratories.
  - Assesses resource requirements for maintaining scientific and technical capability for "leading edge" research and development at the laboratories.
  - Provides overall program planning and direction and necessary resources to the laboratories.

- Operations Offices:
  - Function as laboratory contract officer and implement Headquarters policy and guidance.
  - Work with the laboratories in developing institutional plans and ensure laboratory compliance with approved institutional plans.
  - Ensure integrity of laboratory accounting, budgeting, procurement, and health and safety functions.
  - Assess periodically management, administrative, and cost performance; maintenance of the laboratory; and, in conjunction with Headquarters, the quality of technical performance.
  - Integrate, approve, and monitor work for others to assure consistency with DOE policy and guidelines.
  - Direct laboratory programs wherever management responsibilities have been decentralized and assigned to the operations office.

- Multiprogram Laboratories:
  - Maintain and apply highest quality of scientific, technical, and management talent and facilities to advance DOE goals.
  - Manage and implement assigned programs.
  - Complete assigned work within approved cost schedule and technical baselines.
  - Determine resources for maintaining adequate scientific and technical capability.
  - Create and maintain an intellectual environment optimized for creative scientific activity.
  - Plan for the future taking into account changing science and technology and changing national needs.
  - Maintain a cooperative interchange with university and industry sectors and make available to them research facilities and technical information.

DOE/ER-0123
Volume 1 of 2
UC-4-25-32 & 34c

# AN ASSESSMENT OF THE BASIC ENERGY SCIENCES PROGRAM

## *VOLUME I — TECHNICAL REPORT*

March 1982

U.S. DEPARTMENT OF ENERGY
OFFICE OF ENERGY RESEARCH
OFFICE OF PROGRAM ANALYSIS
WASHINGTON, D.C. 20545

Attachment 3

## SUMMARY

At the request of the Acting Director of Energy Research, an assessment was undertaken of the Office of Basic Energy Sciences (BES) program. Out of approximately 1200 active projects supported by BES, a randomly selected sample of 129 projects was reviewed by panels of scientific peers. The reviews were conducted by 40 separate panels with an average of four members per panel. The panels rated individual projects on the basis of quality of science, quality of the project team, and probable impact on the Department of Energy (DOE) mission. After discussions of the component ratings, an overall panel rating was formed.

All of the ratings in the assessment were on a scale of 0-10. For each rating variable, a set of descriptors was provided which defined intervals on the scale. In all cases, the descriptors for 5-10 had the sense of project quality ranging from acceptable to outstanding; and descriptors below 5 had the sense of a project having serious deficiencies.

These ratings were used to make statistical inferences concerning the BES program. There was substantial uniformity in the judgments of the panel members. The mean of the standard deviations of panel members' ratings of individual projects was less than 1.0 (on the scale of 0-10) for the 129 projects reviewed.

Overall, the peer review panels gave the BES program high ratings in quality of science, quality of project team, and mission impact. Based on the ratings of the sample projects, the peer review examination found that a large percentage, about 60 percent, of active BES projects are of high

overall quality (rated 7 or above); indeed, about 10 percent were rated 9 or above and were judged to be of exceptional excellence. It was further found that most of the projects, about 90 percent, were acceptable or better (rated 5 or above). Only a small fraction, about 10 percent, were judged as having significant shortcomings (rated less than 5).

Each of the BES program areas received high ratings on quality of science, quality of project team, and relevance to the BES mission. Based on the analysis of the sampled projects, it was estimated that for all areas, the percentage of acceptable projects does not fall below 88 percent; the estimates for most program areas were comfortably above that figure. Estimates of the proportion of projects in each of the program areas rated at or above thresholds of 5, 7 and 9 are given in Table S-1.

TABLE S-1: Estimates of the Proportion of Active BES Projects *At or Above Selected Rating Thresholds

| Program Area | Proportion At or Above Threshold | | |
|---|---|---|---|
| | 5 | 7 | 9 |
| Materials Sciences | .90 | .63 | .04 |
| Chemical Sciences | .88 | .57 | .11 |
| Biological Energy Sciences | .93 | .64 | .07 |
| Nuclear Sciences | .96 | .64 | .00 |
| Engineering, Mathematics and Geosciences | .97 | .49 | .22 |
| Advanced Energy Projects | .91 | .73 | .00 |
| Overall BES | .91 | .59 | .10 |

---

* The estimated proportions are subject to sampling error and other sources of variability.

S-3

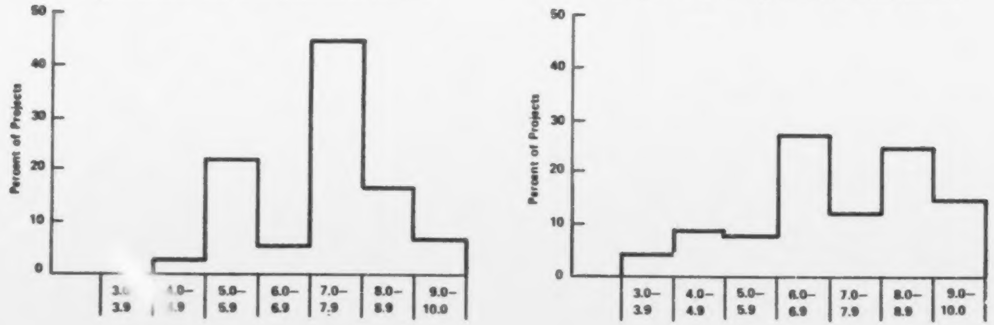
In addition to the analysis of the program as a whole and of the six program areas, studies were made concerning the project ratings in relation to level of funding, institutional type, and length of time the project had received continuous support.

Relationship of Performing Institution Type to Overall Project Ratings

The ratings of laboratory and non-laboratory projects were examined. Because of the direct relationship between funding levels and overall project ratings, the comparison is made in a funding range in which the funding distributions of laboratory and non-laboratory projects are relatively equal.

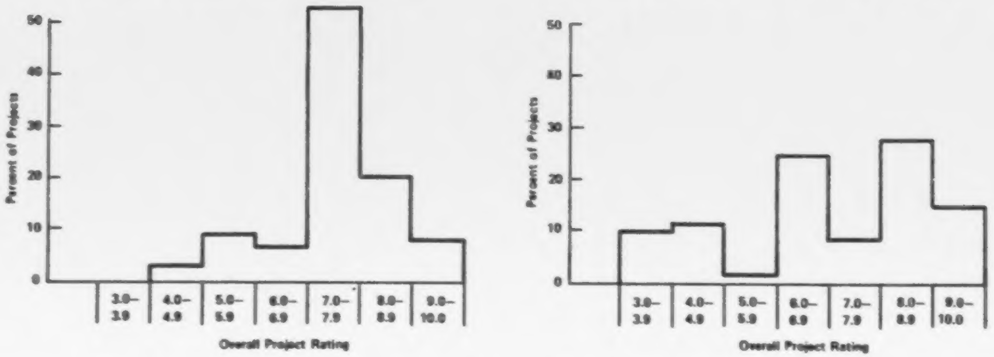
It is noted that 87 percent of the projects in the sample with funding below $75 thousand were performed outside of the DOE laboratories and 86 percent of the projects above $350 thousand were performed at the DOE laboratories. Because of the obvious disproportions, projects in these funding regions were excluded from the comparison.

The laboratory and non-laboratory projects in the $100 to $350 thousand funding range are compared in Table III-5. A sensitivity analysis was performed on the effect of lowering the lower bound which indicated that the comparison of laboratory and non-laboratory projects is insensitive to varying the lower bound within the range $75 to $100 thousand. Figure III-7 presents the ratings in the form of histograms.



A. Laboratory (Funding Between $75 & $350 Thousand)

B. Non-Laboratory (Funding Between $75 & $350 Thousand)



C. Laboratory (Funding Between $100 & $350 Thousand)

D. Non-Laboratory (Funding Between $100 & $350 Thousand)

Figure III – 7 Histograms of overall project rating for laboratory and non-laboratory projects in the funding ranges indicated

TABLE III-5: Results of a Chi-Square Test of the Proportion of Laboratory Projects Rated At or Above a Given Threshold Compared to the Proportion of Non-Laboratory Projects Rated At or Above the Same Threshold in the Funding Range $100 to $350 Thousand

| Rating Threshold | Proportion of Projects At or Above Threshold<br>Laboratory | <br>Non-Laboratory | Chi-Square |
|---|---|---|---|
| 5.0 | .97 | .78 | 0.62 |
| 7.0 | .82 | .51 | 2.35 |
| 9.0 | .08 | .15 | 0.62 |

These comparisons indicate that there is no significant difference in the overall project ratings between the laboratory and non-laboratory projects.

Laboratory and non-laboratory projects were compared for the two largest BES program areas, Materials and Chemical Sciences, in several funding ranges. In the case of the Chemical Sciences projects, the differences in proportions of laboratory and non-laboratory projects rated equal to or greater than 5.0 are significant in some but not all funding ranges. The differences in the proportion of projects in the 7.0 or above category are not significant in any funding range. In the case of the Materials Sciences projects, the proportion of laboratory projects rated at or above 7.0 is significantly higher than the proportion of non-laboratory projects similarly rated in the funding ranges $75 to $350 thousand, $100 to $350 thousand, $60 to $500 thousand, and unrestricted.

# SIGNIFICANT ACCOMPLISHMENTS ILLUSTRATIVE OF MULTIPROGRAM NATIONAL LABORATORY RESEARCH

April 6, 1982

1

## AMES LABORATORY

- The Ames Laboratory developed efficient reduction and purification processes for uranium, thorium, the rare earths, zirconium, hafnium, yttrium, and vanadium. All of the processes have been adopted by industry, and all are in use today. Essentially all of the uranium used in the Western world has been prepared by the Ames process, and the entire rare earth industry is largely dependent upon the basic separations and chemical, metallurgical, and materials characterization achievements of this Laboratory (1940 to present).

- The development of the inductively coupled plasma atomic-emission spectroscopy method for multi-element analysis was carried out at the Laboratory. The method is very fast, requires minute amounts of sample, and permits simultaneous identification of up to 50 elements; for most of these elements, this method is more sensitive than any other. Commercial instruments based on this development have been introduced: six U.S. and eleven foreign companies are now marketing such instruments at a sales rate of about $100 million per year (1970s).

- Development of a ductile, composite superconducting wire suitable for large-scale magnets in the 12- to 14-tesla range was carried out by an interdisciplinary team of metallurgists and solid state physicists at Ames Laboratory. The material is easy to fabricate and has the high strength and strain tolerance needed for toroidal field magnets in Tokamak fusion reactors (1970s to present).

- The Ames Laboratory developed the basic science for sampling, isolating, and quantitating the trace organic compounds in water. The isolation techniques have increased detection power approximately 10,000-fold for most compounds of environmental interest. The methodology has been adopted nationally and internationally by government, university, and industrial laboratories (mid to late 1970s).

- Recently a reactive radio frequency sputtering method for the preparation of hydrogenated amorphous silicon films for solar cells was developed here. The method permits the preparation of large-area films needed for solar panels while retaining the careful control of the local environment of the hydrogen ions, which is needed for high performance (1978 to present).

- Very recently a method based on high-resolution solid state nuclear magnetic resonance in coal samples has been developed for determining the sizes of the polynuclear aromatic rings in the molecular structure of coal. These results, compared with similar results on liquid fuels produced from coal, are used to study the effects of the chemical processing steps in liquefaction (1978–1980).

- The Laboratory has also recently completed the development of a laser/mass spectrometer probe capable of detecting 62 elements present in concentrations as low as 1 ppb in phases of solids whose dimensions are as small as 10 to 20 μm and it is applicable to metals, semiconductors, and insulators. Accurate analyses can be made without the use of standards (mid 1970s to present).

- Chemical engineers and materials chemists at the Ames Laboratory have developed methods for improved control of the complex chemical equilibrium governing the separation of plutonium from uranium in fuel processing. The programs developed in the work are now being used in nuclear safety and nuclear safeguards programs in the United States (1973–1976).

- The development of a liquid junction solar cell using $WSe_2$ and $MoSe_2$ with efficiencies of 10% and 9.5% and no detectable photocorrosion of the electrodes after extended illumination was recently carried out by an interdisciplinary group from the Materials Chemistry and Solid State Physics divisions at Ames (1977–1980).

- Ames Laboratory scientists are responsible for the recent development of a provisional international practical temperature scale for use by the entire scientific community. A large portion of fundamental research between 0.5 and 35 K was done by the Laboratory, and the scale was adopted by the International Commission on Weights and Measures (CIPM) (1975–1976).

## ARGONNE NATIONAL LABORATORY

- Water-cooled nuclear reactor research, design, and development at Argonne National Laboratory contributed significantly to the establishment of the nuclear power industry and in the nuclear-powered submarine. The Laboratory still provides reactor and reactor waste safety information (1946 to present). This capability was applied to the following projects:

  1. design of the first land-based prototype submarine reactor,
  2. design of the first reactor using heavy water as a moderator and coolant,
  3. basic design of the Savannah River production reactors, and
  4. development of the boiling water reactor concept [Boiling Reactor Experiments (BORAX), Experimental Boiling Water Reactor (EBWR)].

- Liquid-Metal Cooled Fast Breeder Reactor (LMFBR) research, design, and development at Argonne provided the technology foundation for these reactors and continues to provide component and materials testing and evaluation. It has accumulated 16 years of LMFBR operational experience in the production of electricity. This research produced the following advances:

  1. design of the first successful breeder reactor (EBR-I), which produced the first usable amounts of nuclear-generated electricity;
  2. development of fast reactor and high-temperature reactor fuel materials; and
  3. development of the world's first transient reactor test facility (TREAT) to study fuel behavior during sudden power surges (1946 to present).

- A prototype superconducting linear heavy-ion accelerator is operational. When a total of seven modules are completed, the Argonne Tandem-Linac Accelerator System (ATLAS) will be able to provide 1.5-GeV particles, previously unavailable, that will improve understanding of nuclear binding forces (1979 to present).

- Intense Pulsed Neutron Source-I (IPNS-I) provides the world's most powerful source of non-reactor neutrons, which will be used to study radiation effects in fission and fusion reactor materials. Other applications will include areas of physics, chemistry, and biology (1971 to present).

- Zero Gradient Synchrotron (ZGS) acceleration of polarized protons was used to study spin-spin interaction between protons at high energy. Contrary to the existing belief, spin effects were shown to be large (1971–1979).

- Liposome encapsulation, the technique of coating minute amounts of a drug with naturally occurring fatty substances called phospholipids, was developed at Argonne. The microscopic capsules formed by this technique penetrate individual cells, where the fatty coating is dissolved by enzymes and the drug is allowed to do its work without having been weakened or diluted by the body's defense systems. When applied to cancer chemotherapy, liposome encapsulation allows the destruction of diseased cells from within, while leaving nearby cells unharmed. Eleven companies are currently using the technique to improve the efficiency of their anti-cancer agents (1973 to present).

- ISO-DALT, a two-dimensional electrophoretic system that separates and maps human serum proteins together with TYCHO image analysis and the KEPLER data base, will become a powerful diagnostic tool for extremely early detection of many diseases in man and will be applicable to large populations (1978 to present).

- Mathematical software has been designed and developed, including EISPACK for eigenanalysis, FUNPACK for approximations of special functions, LINPACK for solution of linear systems, MINPACK for numerical optimization, and SPEAKEASY for matrix manipulations. There is also AURA, which functions as an "automated reasoning assistant" and interacts with the scientist to solve problems. Distribution on EISPACK alone includes over 1000 research centers in over 70 countries (1972 to present).

- The world's largest high-field superconducting magnets, used in magnetohydrodynamics generators of electricity and in high-energy-physics bubble chamber experiments, have been designed and developed (1963 to present).

- Fluidized-bed combustion is a technology that has been developed to permit the use of high sulfur coal. Ninety percent of the sulfur combines with limestone during combustion, thereby reducing air pollution. Attention is now focused on recycling the limestone (1963 to present).

## BROOKHAVEN NATIONAL LABORATORY

- The large particle accelerators that Brookhaven National Laboratory (BNL) has designed, built, and operated as national facilities have been the sources of many discoveries in particle physics which have led to a deeper understanding about the nature of matter. The first observation of a charmed baryon was made at BNL; and two recent Nobel prizes in physics, 1976 and 1980, were awarded for work carried out at BNL: the discovery of the J/psi particle in 1974 and the experiment which showed the violation of a fundamental symmetry principle in 1963.

- By the middle of the 1970s, sufficient data were obtained from a 600-ton solar neutrino detector situated 1 mile underground to show that either our current views of the details of the nuclear reactions generating the sun's energy are incorrect or that our understanding of the fundamental properties of neutrinos is not complete. Since both of these possibilities are of great interest, a new experiment designed to eliminate one of them is under way.

- The animal model developed at BNL, a specific species of rat, the Dahl S&R, was first used to show the genetic linkage between sensitivity to environmental stress, including dietary salt, and the likelihood of developing hypertension. These rats continue to be widely used for much of the present laboratory work on this disease.

- The invention at BNL of a procedure by which the short-lived radiopharmaceuticals such as $^{99m}$Te and $^{201}$Tl could be effectively distributed and used by the medical community started a new generation of nuclear medicine applications. These two isotopes account for approximately 75% of the domestic radiopharmaceutical business in the United States, a sales level of $85 million.

- The pioneering work on the therapeutic use of L-Dopa for the treatment of Parkinson's disease was carried out at BNL. This drug continues to form the foundation for the treatment of this disease today (early 1970s).

- The labeling of 2-fluoro-2-deoxy-*d*-glucose with radioactive $^{18}$F at BNL and use of this radiopharmaceutical in conjunction with positron-emission transaxial tomography (PETT) has initiated widespread activity in many new areas of medical research. Regional metabolic activity at accurately determined locations inside the brain can now be measured. The technique has led to a much more detailed understanding of a whole range of phenomena (e.g., drug response) and diseases (e.g., senility, stroke, and schizophrenia) that affect the brain. The National Institutes of Health (NIH) are now supporting about ten centers to carry out this type of work (1976).

- Neutron scattering experiments at BNL's High Flux Beam Reactor have definitely established the nature of the magnetic state and its competition with superconductivity. This crucial step in relating these two very fundamental and technologically important properties of materials will eventually lead to deeper understanding and more sophisticated applications of these properties (1976 to present).

- The first demonstrated transformation of human cells in culture by ultraviolet light was shown at BNL in 1980; this discovery now opens the way for laboratory studies of cancer-producing mechanisms.

- The first correlation between the ability to repair damage to DNA and the life span of different mammalian species was discovered in 1974 by a BNL scientist who is now investigating the relationship of DNA repair to aging in humans.

## LAWRENCE BERKELEY LABORATORY

- The Lawrence Berkeley Laboratory (LBL) has been responsible for numerous major advances including the invention of the cyclotron, the linear accelerator, the synchrotron, and continuing contributions to new particle accelerator concepts and construction projects (1929 to present).

- The creation and identification of 15 new chemical elements, including plutonium, by nuclear synthesis was carried out by scientists at LBL (1940–1976).

- Particle research conducted by scientists at the Laboratory led to the discovery of the antiproton and numerous excited states of the fundamental particles (1955–1965).

- The Laboratory became one of the world's major centers of heavy-ion nuclear physics research by (1) adapting the 88-Inch Cyclotron to the acceleration of heavy ions (1971); (2) connecting the SuperHILAC heavy-ion accelerator to the Bevatron to make the Bevalac (1972); and (3) improving the Bevalac (1981) to provide acceleration of ions as heavy as uranium to multi-billion-volt energies, a capability unavailable anywhere else in the world. SuperHILAC, Bevalac, and 88-Inch Cyclotron accelerators serve as national facilities for nuclear physics and biomedical research (1971 to present).

- The LBL was responsible for the founding of the National Center for Electron Microscopy equipped with instruments of highest energy and highest resolution (1980 to present).

- The Laboratory was also responsible for the founding of the science of nuclear medicine (1935), the continued development of instruments and techniques for the beneficial use of gamma and particle radiations (1935 to present), and the exploration of use of heavy ions for treatment of cancer.

- The Laboratory has contributed significantly to discoveries and developments in high energy physics: for example, discovery of the $\psi$ family of particles, the discovery of charmed particles, the design and construction (with Stanford Linear Accelerator Center) of the Positron-Electron Project accelerator, the design and construction of the Mark I and II massive detector systems, the design of the Time Projection Chamber superconducting magnet, and the development of stochastic beam cooling (1974 to present).

- The Laboratory has also done research and development on particle injection into fusion reactors for heating and fueling and design and construction of neutral beam injectors for Lawrence Livermore National Laboratory's 2X-IIB, Princeton's Tokomak, and General Atomic's Doublet III (1974–1981).

- A large-scale field experiment was conducted in an iron mine in Stripa, Sweden, to measure rock characteristics significant to underground storage of nuclear wastes (1976).

- The LBL has been responsible for the development of instruments now used in hundreds of university and corporate laboratories for precise measurement of gamma radiation, x rays, nuclear particles, chemical elements, chemical compounds, magnetic field strengths, and other properties (1950–present).

## LAWRENCE LIVERMORE NATIONAL LABORATORY

### Weapons

- Since its establishment in 1952, LLNL, in conjunction with Los Alamos and Sandia, has continued to function as an integral scientific and technical element of the nation's nuclear weapons program including all facets of nuclear weapon technology and the supporting scientific and engineering disciplines. Particularly, significant achievements have been made in such areas as reduction in size and weight, and enhanced safety, flexibility, and military effectiveness of nuclear weapons. These advances in design have enabled the defense community to provide the nation with increasingly effective warhead capabilities for its nuclear weapons systems.

### Nonweapons

- Under inertial confinement fusion, LLNL developed the technology for 100 TW Nd:glass laser systems. This technology, now adopted as the international workhorse for ICF research, was successfully transferred to U.S. industry in 1975. In addition, LLNL developed the first ultrafast (~20 psec) x-ray streak camera (now becoming commercialized) and the first use of microfabrication technology for high resolution imaging of alpha particles and x-rays (1976–1978). In integrated fusion experiments, the Laboratory provided the first confirmation of laser induced thermonuclear reactions (1975), the first demonstration of energy scalable ablative implosions(1976), and achieved a systematic scaling of imploded fuel density, up to 100 times liquid density, on the Shiva laser facility (1978–1979). Also definitive improvements in target performance at visible and ultraviolet wavelengths were demonstrated on the Argus laser facility. For fusion energy applications, LLNL researchers conceived and assessed the excimer laser driver and the HYLIFE reaction chamber, which features a long-lived (30 year) liquid lithium "first wall" (1977–1981).

- Within the Atomic Vapor Laser Isotope Separation (AVLIS) Program, researchers separated uranium isotopes (1974); demonstrated macroscopic uranium enrichment utilizing critical subsystems scalable to production plant size (1978); developed a high-power tunable (isotopically selective) laser system which is economically competitive (1981); and activated a full-scale uranium vaporizer unit (1981).

- Livermore's involvement in magnetic fusion research dates from the founding of the Laboratory in 1952. As lead laboratory for the National Magnetic Mirror Program LLNL achieved thermonuclear plasma temperature with near-classical confinement in the 2X-IIB experiment (1978); demonstrated the adaptation of the mirror concept to an efficient reactor design in TMX (1980); developed, with LBL large neutral beam systems used for heating plasma (1977); and developed large, high-field superconducting magnets Baseball II and Mirror Fusion Test Facility, MFTF (1981), which enhance related energy technologies like magnetohydrodynamics.

- Livermore has pioneered in underground engineering and experiments for weapons applications. Transfer to nonweapons applications includes rock fracturing for fossil energy applications and incorporating high-level radiation wastes in crystal lattices of synthetic rocks that are related to natural minerals with extremely long-period stability. In-situ coal gasification was demonstrated in experiments at Hoe Creek, Wyoming (1979), that produced a medium BTU gas suitable for chemical synthesis or upgrading to pipeline quality. Industry has contributed resources to this effort.

- Beginning in 1972 and building on the foundation laid by LANL, LLNL has been a world-wide leader in the development of analytical cytology (flow cytometry, flow sorting, computer-based scanning microscopy, cytochemistry) and its application to energy-related toxicology. The laboratory has founded the new field of flow cytogenetics in which chromosomes are analyzed at high speed and resolution, and can, for the first time, be purified by type. LLNL researchers are also pioneering the application of analytical cytology to rare event detection, most noteworthy of which is the detection of somatic mutant cells in human blood. A practical assay for human somatic mutation would be a major breakthrough in the interface between preventive medicine and modern technological development.

- The Laboratory was also responsible for the development of the Atmospheric Release Advisory Capability (ARAC) System for predicting the exposure consequences from accidental releases of radioactivity with real-time communications to system sites. Conceptual studies were done in 1972; limited implementation occurred between 1974 and 1976; and the system was applied to the Three Mile Island (TMI) accident and Kemeny Commission studies in 1979 and to the TMI Purge in 1980.

- Precision engineering and machining techniques for the design, fabrication, and inspection of highly precise mechanical workpieces have been under continual study and development since 1955. Two diamond turning machines were constructed (1968–72) for unprecedented accuracy in the machining of parts, and a third is in development. Assistance has been provided in transferring this technology to industry.

- A systems study of the aluminum-air power cell and its use in automotive propulsion, including performance, cost, and energy efficiency estimates was completed (1980). With industrial participation, the Laboratory is now developing and evaluating a prototype metal-air power cell as an automotive energy source with the range, acceleration, and rapid refueling capability of current internal-combustion engines.

# LOS ALAMOS NATIONAL LABORATORY

## Weapons

- Established in 1943, Los Alamos National Laboratory (LANL) developed the first fission and thermonuclear weapons. In conjunction with Sandia and LLNL, LANL has continued to maintain U.S. superiority in all facets of nuclear weapons technology and supporting scientific and engineering disciplines. Enhanced safety, flexibility, and military effectiveness have been produced through a reduction in size and weight of the weapons. These advances in design have enabled LANL to provide increasingly effective warhead capabilities for integration into a number of defense systems serving every branch of service.

## Nonweapons

- Examples of major Los Alamos accomplishments before 1970 include designing, building, and operating the world's first plutonium-fueled fast reactor and the world's highest temperature and power density fission reactors, thereby establishing possibilities for advanced fission systems and eventual process heat applications. Los Alamos also achieved the first laboratory demonstration of controlled thermonuclear fusion, thereby establishing the possiblity of eventual electricity production from fusion reactions.

- The Molecular Laser Isotope Separation (MLIS) Process for the enrichment of uranium has been developed to the point of demonstrating process feasibility. If developed to production scale, the MLIS process would result in a significant reduction in energy consumption and cost compared to diffusion and centrifuge technology. In response to the needs of the MLIS Program, state-of-the-art advances have been made in the area of laser research and development. The high-power, electric discharge excimer laser operating on all rare gas-halogen combinations has been successfully developed primarily at Los Alamos and by the Laboratory's direct contractors. In addition, LANL has pioneered the development of pulsed isotopic carbon dioxide lasers having long operating lifetimes and a high degree of stability. LANL contractors have produced the first high repetition rate, stable isotopic carbon dioxide lasers at the kilowatt/kilohertz level.

- Fast reactor fuels of plutonium carbide developed by Los Alamos successfully attained specific power production ("burnup") of over 150,000 mwd/ton (1981). This is much higher than that offered by present oxide fuels now used in breeder reactors. The new fuel has also demonstrated the capability of undergoing severe heating transients without performance degradation, an important safety feature. The combination of the improved thermal, mechanical, and neutronic performance of carbide fuel could lead to significant savings in fast-reactor fuel fabrication costs and in overall plant and operating costs as well.

- Special plutonium fuels using a Los Alamos oxide of $^{238}$Pu and $^{16}$O now provide long-life, stable, low background heat sources which generate electricity for experiments on the moon and on the Voyager spacecraft. Newly developed general purpose heat sources employing the same material will be combined in modular arrangements to power the Galileo Deep Space Probe and the Polar Orbiter solar studies mission. The same material, used in smaller radioactive heating units, has numerous space and terrestrial applications.

- Reactor transient codes designed by Los Alamos have been used to understand the behavior of complete nuclear reactor systems under accident conditions. These computational methods were successfully applied shortly after the Three Mile Island accident to reproduce that plant's behavior during the accident. Developments now under way suggest that this computational skill can be incorporated into high-speed microprocessor units at the power plants. This would give their operators rapid analysis during the course of a potential accident, guiding their response more surely to prevent the accident or reduce its consequences.

- The idea of extracting geothermal energy from structurally sound subterranean "hot dry rock" found nearly everywhere was conceived at Los Alamos 8 years ago and has already had a first demonstration of technical feasibility. Heat transfer surfaces were created by fracturing the hot rock between deep drill holes and connecting the holes above ground to form the world's first closed loop geothermal energy system. This environmentally-clean recirculating system produced an average 2.6 megawatts (MW) of power for over 10000 hours, and a portion of that was regularly used to generate onsite electricity up to 60 kilowatts (kw). Now, under joint sponsorship of the USDOE and the governments of West Germany and Japan, a larger (35 MW) engineering system is being constructed (in 300°C rock at 4050 m depth) to demonstrate commercial feasibility. The project has already advanced that state of the art in hard rock drilling and has pioneered in deep drilling (2-3 miles) at high temperatures. Many of the new high-temperature downhole tools and instruments developed for this work have already been adopted by industry. Prospecting techniques developed at the Laboratory are now being used to define and map the more readily accessible parts of this enormous nationwide resource.

- Flow cytometry, developed at Los Alamos, is automatic high-speed sorting of thousands of specific cells, chromosomes, etc., per second using laser illumination of individual cells to measure and select cell size, structure, and chemical composition (1972). This newly transferred technology is already worth several million dollars annually to industry. It is used in health research laboratories and is entering medical and clinical use. It is being applied to disease diagnosis and identification of genetic diseases and tumor cells; it is also being used to study the effects of radiation therapy, drugs, or toxic agents on cells and to develop chemotherapeutic cancer treatment schedules. An emerging application may make it possible to quantify the importance of chromosome aberrations as biological markers for chemical exposure (1972).

- Nonconventional hard materials are a very recent development that may replace tungsten carbide-cobalt in armor-piercing munitions, machine tool bits, mining drill bits, and other applications where high hardness and abrasion resistance are important. These materials do not require strategic materials or cobalt and will use less tungsten. This development has both commercial and defense applications (1981).

- Accelerator developments at Los Alamos have found many practical applications. The mid-1960s discovery of the side-coupled cavity concept greatly increased the efficiency of transferring power to linear accelerator beams and is now adopted almost universally. Recently, LANL has learned how to apply the RF quadrupole bunching and guidance concept successfully to the low-velocity portions of ion linear accelerators. Essentially all such new machines are expected to adopt this technology as well. At the Los Alamos Meson Physics Facility (LAMPF), an accelerator which is nationally and internationally used, researchers have pioneered in the treatment of deep-seated human tumors by pion radiotherapy. Clinical successes and availability of the above technological improvements have encouraged the development of a compact machine especially optimized for hospital use. It is called PIGMI (Pion Generator for Medical Irradiations), and its design concepts are being shared with domestic companies and companies in Japan and Sweden.

- A program for the separation of isotopes of carbon, nitrogen, and oxygen (ICONs) has produced kilogram-per-year quantities of $^{13}C$, $^{15}N$, $^{17}O$, and $^{18}O$. The unique 225-m long, cryogenic distillation column of this program is the major source of these isotopes in the western world. The separated stable isotopes are utilized in physical and biomedical sciences and in environmental studies through basic research programs and extensive cooperative ventures with universities and medical schools.

## OAK RIDGE NATIONAL LABORATORY

- Oak Ridge National Laboratory (ORNL) served for over 30 years as the principal developer and reference source for models and techniques to estimate radiation doses received by humans. Essentially all nations have uniformly adopted usage of the ORNL models and techniques through the recommendation of the International Commission on Radiological Protection (1940s to present).

- The Laboratory has developed advanced centrifuge techniques for producing pure vaccines and for performing rapid medical diagnoses. These are now in wide-scale commercial use (1965–1975).

- The development of radionuclide production for nuclear medicine applications was initiated at ORNL, and, in conjunction with medical schools and hospitals, the Laboratory developed efficient radiopharmaceuticals as imaging agents to study heart disease and locate brain tumors (1945 to present).

- The first heavy-ion cyclotron was constructed at ORNL, and the field of heavy-ion physics was founded by establishing the general properties of heavy-ion elastic scattering, transfer reactions, and compound nuclear reactions (1950 to present).

- Crucial determinations were made of neutron radiation damage, including radiation-induced creep, in metals and alloys; contributions in this area have been necessary for the development of nuclear reactors (1949 to present).

- Theory and supporting data for the design of heavy section steel vessels were developed at ORNL. The results of this program have provided an assurance of safety necessary for the light-water reactor (LWR) pressure vessel, which has been accepted by regulatory bodies both in the United States and other countries (mid-1960s to present).

- The Laboratory provided rapid and extensive assistance during the Three Mile Island incident, from the beginning until now. Radiochemical, chemical, and isotopic measurements were made, along with a variety of physical tests. ORNL developed the process flowsheet for the cleanup of the water from the containment building. ORNL also resolved the question of why iodine releases were so low and showed that much lower iodine releases than previously predicted would occur in many LWR accident scenarios (1980 to present).

- For nuclear fuel reprocessing, ORNL developed Purex (1953), Thorex (1958), and Remotex (1980). Purex and Thorex processes are now used in all known fuel reprocessing plants throughout the world. Remotex is a fully remote processing concept which has been used for most radioisotope systems and also has been applied to the handling of hazardous materials such as carcinogenic compounds.

- The major contributions to the development and application of neutral injection heating for fusion were made at ORNL. These include the development of the initial physics and technology, as well as a prime contribution to the initial applications and understanding of this important plasma heating technique (1969 to present). Devices were also developed at ORNL which, in conjunction with the Princeton Plasma Physics Laboratory, produced a 70 million degree plasma in the Princeton Large Torus (1978).

- A broad array of instrumentation and monitoring techniques for fossil-energy-related applications was developed that provides the basis for work area monitoring for industrial hygiene purposes of a broad class of carcinogenic polyaromatic hydrocarbons (PAH) which are produced in coal conversion reactions. The instruments include the derivative ultraviolet absorption spectrometer (DUVAS) for detection of specific gaseous organic emissions, the portable "spill spotter" for detection and quantification of work surface PAH contamination, the light-pipe lumminoscope for detection of PAHs on skin, and a personnel monitor for determining individual worker exposure to volatile organics, including PAHs (1977 to present).

## PACIFIC NORTHWEST LABORATORY

- The Pacific Northwest Laboratory (PNL) successfully demonstrated the immobilization of high-level waste from the nuclear fuel reprocessing of six commercial fuel assemblies in a stable glass form for storage (1976–1979). The process is being transferred to the Savannah River Laboratory for use in the Defense Waste Processing Facility. It will be used in the West Valley Demonstration Project to solidify the liquid high-level wastes stored in tanks at the site.

- For over 30 years the Laboratory has conducted experimental research that has led to major improvements in nuclear power plant and core fuel performance, core life, plant safety, and plant factors. This research has included a cooperative program (1973–1975) with Japan and several European countries that led to resolution of fuel densification questions threatening shutdown of numerous nuclear power plants in the United States and throughout the world.

- The Laboratory established the technical, health, and environmental basis for the private-sector use of mixed oxide (plutonium and uranium) fuels in light water reactors (1960–1970). The studies have led to a technology base for a better understanding of the use of uranium oxide and mixed oxide fuels. The technology was adopted by one corporation as a new venture of providing mixed oxide and uranium oxide fuels that has grown to a multihundred million dollar fuel reload business with a billion dollar backlog (1967–1975). Also, critical mass data for plutonium, uranium, and mixtures of the two provided information used by industry to design nuclear fuel cycle facilities and equipment (1967 to present).

- Electropolishing and vibratory-finishing techniques for decontaminating metal surfaces were developed at PNL. These techniques are being used for the cleanup at Three Mile Island; they have been incorporated in mobile decontamination units operated by seven commercial companies; and they are factored into decontamination plans of most DOE sites (1975–1980).

- An advanced cooling-tower process that uses little or no water was developed; this is an important alternative for arid western states or other regions of uncertain future water supply. The concept is being demonstrated by the private sector at a utility power station and holds the potential of 30 to 40% cost reductions over existing dry-cooling technology (1974–1981).

- High-rate and large-volume sputtering processes have been developed for the versatile fabrication of special-purpose materials and coatings. The technique has been used for coating turbine blades for increased reliability, fabricating materials for high-energy-laser mirrors, and trapping krypton gas in metals in order to meet release criteria for nuclear reactors and other nuclear facilities (1969 to present).

- Experiments on effluents and products from coal conversion processes conducted for about six years suggest that mutagenic and probably carcinogenic effects of coal liquids are due to a relatively small fraction of the constituents of coal conversion liquids. Mutagenic effects are due to primary aromatic amines. Also, researchers found that coal liquids, because of their high phenol content, are more toxic to aquatic organisms than petroleum and petroleum-based fuels. Hydrotreatment of the coal liquefaction materials reduces these toxic constituents and is expected to ameliorate effects. Results are being used by industry to (1) develop alternative coal conversion processes that produce less phenol and fewer primary aromatic amines, (2) modify processes to remove these mutagenic and toxic constituents, and (3) assess potential environmental and health impacts of a commercial coal liquefaction industry (1976–1981).

- The Laboratory has developed a cationic asphalt emulsion that can be used to seal radon gas in piles of uranium tailings. The new emulsion forms a tight electrostatic bond with the soil rather than the usual mechanical bond. Results after six months of a field study with the new emulsion indicate a greater than 99.99% reduction in the amount of radon gas normally released from uncovered tailings (1978–1981).

- Health and environmental studies of radionuclides have been conducted at Hanford for over 30 years using Hanford-developed instruments and procedures for low concentration measurements. Health effects of transuranic (radioactive) elements were measured as a function of body entry route, specific radiation compound, and animal species and ages. Possible synergistic and antagonistic effects of combined exposures to transuranic elements and nonnuclear environmental contaminants were determined. Effects of environmental exposure routes and mechanisms of biological availability of transuranic elements were also ascertained. These data are widely used in setting or jutifying existing radiation exposure standards and as a basis for resolving issues and making decisions. For example, results from studies of plutonium have clarified questions about potential health effects of plutonium and the issue of "hot particles"; and results from krypton inhalation studies supported the decision to vent krypton gas at Three Mile Island (1977-1981). The extreme measurement sensitivities resulting from the instrumentation developments and radioanalytical procedures have been used for meteorite and lunar sample analysis, exploitation of mineral resources, nuclear proliferation control, and categorization and characterization of pollutants from all phases of energy production.

- The Laboratory has been instrumental in developing siting and methodology criteria in support of major national programs. In the 1960s, extensive environmental studies were conducted at both Cape Canaveral, Florida, and Vandenberg Air Force Base, California, which established criteria for safety in expanding space programs, including that required for siting of launch facilities. In the early 1970s, in response to new legal requirements for environmental assessment of commercial nuclear facilities, measurement and analysis methods were established to determine the health and environmental impact from nuclear operations. Criteria and procedures developed by PNL for environmental impact statements of nuclear reactors were rapidly deployed and are still used by industry. More recently (1977–1981), siting criteria, realistic wind data, and measurement techniques have been developed that facilitate the use of modern large and small wind turbines in the continental United States. Specific uses of the PNL information and techniques by the private sector include: (1) screening potential sites for power production units; (2) improving site selection capabilities; (3) conducting market studies, economic analysis, and feasibility studies; and (4) diversifying their business to include wind measurements (1962–1981).

## SANDIA NATIONAL LABORATORIES

### Weapons

- Since its establishment in 1949, Sandia has developed safe, reliable, deliverable, field-ready weapons using the nuclear devices developed by LANL and LLNL. Sandia's weapons research and development includes arming, fuzing, and firing systems; command and control systems; and the structural and aerodynamic designs. Significant advances in safety, security, and flexibility of those systems as well as in miniaturization of components and protection against hostile environments have been made. Sandia has also been instrumental in extending component shelf life, thus greatly reducing stockpile maintenance costs. The Laboratory performs these functions for all nuclear weapons in the stockpile. Until about 1973, Sandia's activities were 100% defense related; today about 75% of the staff is engaged in defense activities. Since defense work is classified, representative unclassified examples of accomplishment cannot be supplied except for the nonweapon projects started within the last 5-10 years.

### Nonweapons

- In a program initiated in the early 1970s, Sandia has discovered a family of transparent electroptic ferroelectric ceramics based on lead lanthanum zirconate titanate (PLZT) and has developed unique solid-state devices based on these materials. The applications include image storage, processing, and display devices; light valves and shutters (e.g., flashblinders and welding goggles, spectral and variable density filters); and numeric displays. Over 20 companies and laboratories in the United States and abroad now have active research and development programs on PLZT materials and devices.

- After conducting systems studies of fossil and geothermal processes, Sandia developed more than 2 dozen devices and processes now widely used by industry. Examples are high-temperature microcircuits, coring devices, new drilling muds, new hardrock drill bits, and a downhole combustion device for injecting steam into oil-bearing formations. Since about 80% of this country's heavy oil deposits will be recovered using thermal energy, it is significant that downhole steam generators use less fuel, create less pollution, and recover more oil from greater depths than surface generators. Several commercial firms are in design and manufacture of the device (1974–1982).

- Sandia has managed a significant fraction of the national solar energy program. The Laboratory's systems studies and experience with costs of hardware construction and operation revealed market limitations that were not commonly recognized nor publicized. Over 20,000 industrial and political decision makers have been extensively briefed on the results of this work (1972 to present).

- Sandia's Combustion Research Facility was opened in 1981. Already, experimental results and computer codes from the combustion research program have been used by the automotive industry to modify engine designs for greater fuel efficiency, and theoretical analyses have enabled the oil and power systems industry to devise a technique for significantly reducing a major pollutant product of combustion.

- In 1975 a patent was granted on Sandia's Hot Gas Solder Leveler, which, relative to other solder levelers, reduced process time by 90%, pollution by 95%, and power requirements by 60%. Several firms have manufactured the hundreds of Hot Gas Solder Levelers in use domestically and overseas; annual sales estimates are in the neighborhood of $20 million.

- Since the concept of using laminar airflow to create ultra-clean and contamination-free environments was developed at Sandia in the early 1960s, numerous manufacturers have produced many thousands of clean rooms and work stations for medical, industrial, and other applications. Annual sales in the United States are estimated to exceed $100 million.

- Sandia has identified and developed understanding of very important long-term, low-level radiation damage dose-rate effects in polymeric materials used in nuclear power reactors (1978 to present). This work, which grew out of extensive radiation effects research, has resulted in the worldwide reexamination and rewriting of test methodology for qualification of materials used in nuclear power reactors.

- Experimental and analytical data that reduce the uncertainties in understanding several accidents in commercial nuclear power reactors have been developed here. The program uses Sandia's unique Annular Core Research Reactor (ACRR) as well as other specialized materials test facilities. This program has shown several hypotheses used in designing reactors to be incorrect; these results will yield improved designs for future reactors. Also, the ACRR has allowed reactor safety experiments that produce more accurate assessments of reactor safety (1975 to present).

- Sandia has developed the technology for radiation-tolerant large-scale integrated circuits and transferred this technology to industry. Radiation-hardened microelectronics applications include national security, nuclear reactor instrumentation, satellite-based equipment, and the U.S. space program.

- New concepts and techniques in modular pulsed power, power conditioning, and power concentration that are leading to particle accelerators and similar devices capable of delivering extremely high energies and powers have been developed. These devices are finding important applications in studies of high-energy-density plasmas, the effects of intense radiation on materials, and directed-energy particle beams (1972 to present).

## TECHNOLOGY TRANSFER

### Summary of Significant Accomplishments and Current Efforts

Significant technology transfer has taken place in the past two years, much of it as the result of efforts over a longer period of time.

The following selected accomplishments were reported by the laboratories in FY 1982:

- An ultrathinning technique developed by the Pacific Northwest Laboratory was transferred to the Medical College of Georgia for the study of dental porcelain and dental microanatomy to aid in examination of calcified tissues.
- Sandia National Laboratories designed an electronically controlled pump, derived from weapon technology, that has provided reliable insulin delivery when implanted in diabetic patents. Design and know-how is being transferred to medical equipment manufacturers.
- Idaho National Engineering Laboratory, consulting to State governments on radioactive waste disposal, has helped in the drafting of seven regional plans for establishing disposal sites.
- A Los Alamos National Laboratory developed explosive is being used by industry. Hercules Inc. has obtained a license for geothermal simulation applications and has produced pilot plant quantities of the material for commercial use.
- A heat pump hot water heater, developed by Oak Ridge National Laboratory, has been licensed to four manufacturers, with more companies expected.
- Solar Energy Research Institute developed a solar cell fabrication technology which will be commercialized by Solavolt International. Solar cells have been produced in the 10-12 percent efficiency range.
- Computer controlled cable tensioning equipment developed by Lawrence Livermore National Laboratory as part of the underground testing program has been transferred to the Reliance Electric Corporation. The system is now being marketed for private sector applications, principally in the oil industry.

Attachment 4

- The Ames Laboratory has developed metallurgical processes and fabrication techniques for the in situ production of Cu-$Nb_3Sn$ superconducting wire which are more economical and efficient than the procedures previously used. The Airco Corporation has used the Ames Process in the production of limited quantities of superconducting wire for high strength magnets.

- A geothermal power plant simulation computer program "GEOTHM" has been developed by Lawrence Berkeley Laboratory. It includes models of the properties of geothermal and geopressured brines at high temperatures with the main focus on NaCl and $Na_2SO_4$ solutions with water. Bechtel has used the program in designing two geothermal power plants, one of which is now under construction in the Imperial Valley of California.

- The Morgantown Energy Technology Center has facilitated the transfer of state of the art simulation technology for large coal conversion process plants to private industry by the completion and delivery of the Advanced System for Process Engineering (ASPEN) software package. Developed by MIT under contract to Morgantown, the package is available through the National Energy Software Center and from National Technical Information Service.

We have asked our laboratories to provide us with as much detailed information as possible about the economic value of the technology they transfer. This is a particularly difficult assignment to perform with accuracy, given the resources of the laboratories and the diverse areas and markets that must be analyzed. We will continue in our efforts to acquire the capability to quantify the economic impact of successful transfer. Some estimates of technology transfer impact are as follows:

- Ames National Laboratory estimates an annual sales level of $100 million and over 1500 installations, for the Inductively Coupled Plasma-Atomic Emission Spectrograph developed at the laboratory.

- Los Alamos National Laboratory estimates over $800,000 in business by six instrument manufacturers from laboratory invented technology.

- Oak Ridge National Laboratory estimates over $200 million has been invested by industry since 1978, in the uranium extraction process developed at the laboratory.

- Fermi National Accelerator Laboratory (Fermilab) has been a significant factor in the $100 million per year superconductivity field.

Industry and university use of laboratory equipment under the DOE user facilities program is a particularly practical and effective means of implementing technology transfer. Among the programmatic advantages are greater economic utilization of equipment, the availability to industry and universities of instrumentation and equipment beyond their economic means and, often, a cost sharing that increases the cost effectiveness of the facility. User programs in advanced nuclear projects, cryogenics, superconductivity and microelectronics foreshadow commercial implementation of advances in these and many other programs. At Brookhaven National Laboratories, for example, facilities at the National Synchrotron Light Source are shared simultaneously by Exxon, Bell Laboratories, IBM, GE, and Allied Chemical as well by universities and other Government laboratories.

**U.S. Department of Energy**
**Washington, D.C.**

## ORDER

DOE 5800.1

3-25-82

SUBJECT: RESEARCH AND DEVELOPMENT LABORATORY TECHNOLOGY TRANSFER PROGRAM

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1. PURPOSE. To establish the policy and responsibilities for the management of the Department of Energy (DOE) Research and Development (R&D) laboratory technology transfer program.

2. SCOPE. The provisions of this Order apply to all elements of the Department which are involved in the administration, management, and support of the DOE laboratories.

3. REFERENCES.

   a. DOE 5000.1, INSTITUTIONAL PLANNING PROCESS, of 6-25-80, which establishes policy and responsibilities for administering the DOE multiprogram laboratories.

   b. DOE 5600.1, MANAGEMENT OF THE DEPARTMENT OF ENERGY WEAPON PROGRAM AND WEAPON COMPLEX, of 6-27-79, which establishes policy and responsibilities for management of the weapon complex and program.

   c. Public Law 96-480, The Stevenson-Wydler Technology Innovation Act of 1980, which requires technology transfer by federally funded R&D laboratories.

4. POLICY AND OBJECTIVES.

   a. Policy. It is DOE policy that technology transfer activities as required by Public Law 96-480 are legitimate functions of the R&D laboratories and will be conducted, as appropriate, at those laboratories specified in this Order.

   b. Objectives.

      (1) To establish a Department policy and R&D laboratory technology transfer program responsive to the requirements of Public Law 96-480.

      (2) To require the conduct, as appropriate, of technology transfer activities at the R&D laboratories.

      (3) To assure the application of consistent assumptions and procedures in the planning and conduct of technology transfer activities at the R&D laboratories.

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Director of Energy Research

Attachment 4

(4) To assure appropriate and effective administration and management of the technology transfer program by the cognizant Secretarial Officers assigned responsibility for the R&D laboratories.

(5) To assure the timely and accurate collection of data and information about technology transfer for the purpose of describing the overall DOE effort in the technology transfer program.

5. DEFINITIONS.

a. Technology Transfer. The transformation of R&D into processes, products, and services that can be applied to State and local government and private sector needs. The R&D laboratory technology transfer program emphasizes personal interaction between the technical staff of the R&D laboratories and representatives of the public and private sectors. The R&D laboratory technology transfer program includes the following activities:

(1) Assessment of R&D projects for applicability to the needs of the private sector and State and local governments.

(2) Application and/or adaptation of research or technology into processes, products, and services for use by the private sector and State and local governments.

(3) Technical assistance to the private sector and State and local governments in adapting federally developed technology for use.

(4) Cooperation with technology transfer brokers to move technology from the laboratories to the private sector and State and local governments.

(5) Licensing of DOE-owned patented technology for commercial use.

b. Technology Transfer Brokers. Any institution or organization which provides linkage between the R&D source and the public or private sector utilizing the R&D.

c. Cognizant Secretarial Officers and R&D Laboratories. Attachment 1 identifies the cognizant Secretarial Officers and the DOE R&D laboratories under their purview.

6. RESPONSIBILITIES AND AUTHORITIES.

a. Under Secretary establishes DOE policy and overall guidance for the R&D laboratory technology transfer program. In so doing, the Under Secretary is supported by the Director of Energy Research.

b. Director of Energy Research.

(1) Provides staff recommendations to the Under Secretary regarding policy for the conduct of the technology transfer program by the R&D laboratories.

(2) Provides annual schedule and guidance to cognizant Secretarial Officers for the DOE R&D laboratory technology transfer program. The technology transfer program will include the approval of an annual 5-year technology transfer program plan by the cognizant Secretarial Officers and the submission of an annual technology transfer program report by each laboratory. The development of the guidance will be coordinated with the cognizant Secretarial Officers.

(3) Coordinates the technology transfer program as part of the institutional planning process.

(4) Provides guidance regarding the incorporation of the technology transfer program functions into the existing institutional planning process for multiprogram laboratories. For those R&D laboratories not included in the existing institutional planning process provides guidance regarding utilization of applicable elements of that process so as to avoid creating any new duplicative process or paper requirement.

(5) Coordinates the preparation of an annual technology transfer program report.

(6) Provides an interagency coordination point for technology transfer programs at DOE laboratories as appropriate.

(7) The Laboratory Management Division, Office of Field Operations Management, ER-42, is the focal point for coordinating the technology transfer program and for interagency coordination as appropriate.

c. Cognizant Secretarial Officers.

(1) Assure that the technology transfer program is incorporated into the activities of the R&D laboratories under their responsibility to the extent appropriate and consistent with overall DOE policy.

(2) Coordinate with the Director of Energy Research regarding general policies, assumptions, definitions, and procedures affecting the technology transfer program.

(3) Administer the technology transfer program for the R&D laboratories for which they are responsible.

(4) Incorporate the technology transfer program into the existing institutional planning process for multiprogram laboratories and utilize applicable elements of the institutional planning process for R&D laboratories not now included in that process.

(5) Provide guidance through the appropriate operations office, as applicable, for the R&D laboratories under their responsibility regarding the development and implementation of the technology transfer program consistent with the schedule and guidance issued by the Director of Energy Research.

(6) Approve annual 5-year technology transfer program plan for the R&D laboratories under their responsibility, utilizing the institutional planning process where appropriate.

d. Assistant Secretary, Management and Administration provides support for the technology transfer program at R&D laboratories as appropriate.

e. Assistant Secretary for Defense Programs provides security classification guidance on new areas of information as appropriate.

f. Assistant Secretary for Congressional, Intergovernmental, and Public Affairs provides recommendations to the Under Secretary regarding policy for conduct of and effectiveness of the technology transfer program at the R&D laboratories in regard to State and local governments.

g. Assistant General Counsel for Patents.

(1) Administers patent licensing program of DOE, including granting of licenses to qualified applicants.

(2) Negotiates patent licenses, including charging of royalties where appropriate.

(3) Coordinates with operations offices and R&D laboratories to provide technical assistance to patent licenses when appropriate.

h. Deputy Assistant Secretary for Naval Reactors.

(1) Establishes procedures for all technology transfer concerning Naval reactors information at R&D laboratories.

(2) Approves all technology transfers concerning information in the Naval reactors program.

i. Managers of Operations Offices.

(1) Overview laboratory compliance with the guidance provided by the Director of Energy Research and the cognizant Secretarial Officers concerning the technology transfer program at R&D laboratories under their purview.

(2) Advise and concur in the individual R&D laboratory technology transfer program annual 5-year plans and annual reports.

William S. Heffelfinger
Assistant Secretary
Management and Administration

## R&D LABORATORIES AND RESPONSIBLE COGNIZANT SECRETARIAL OFFICERS [1/]

1. Director of Energy Research.
   - a. Ames Laboratory
   - b. Argonne National Laboratory
   - c. Brookhaven National Laboratory
   - d. Lawrence Berkeley Laboratory
   - e. Oak Ridge National Laboratory
   - f. Fermi National Accelerator Laboratory
   - g. Princeton Plasma Physics Laboratory
   - h. Stanford Linear Accelerator Center
   - i. Bates Linear Accelerator Facility
   - j. Center for Energy and Environment Research
   - k. Environmental Measurements Laboratory [2/]
   - l. Inhalation Toxicology Research Laboratory
   - m. Laboratory for Energy Related Health Research
   - n. Laboratory of Biomedical and Environmental Sciences
   - o. Laboratory of Radiobiology and Environmental Health
   - p. Michigan State University (MSU)-DOE Plant Research Laboratory
   - q. Notre Dame Radiation Laboratory
   - r. Oak Ridge Associated Universities
   - s. Radiobiology Laboratory
   - t. Savannah River Ecology Laboratory
   - u. University of Rochester Biomedical Laboratory

[1/] R&D laboratories are contractor-operated except where noted.
[2/] Government-owned, Government-operated laboratory.

Vertical line denotes change.

2. Assistant Secretary for Defense Programs.
    a. Lawrence Livermore National Laboratory
    b. Los Alamos National Laboratory
    c. Sandia National Laboratories
    d. New Brunswick Laboratory [2/]
    e. Savannah River Laboratory
3. Assistant Secretary for Nuclear Energy.
    a. Pacific Northwest Laboratory
    b. Bettis Atomic Power Laboratory
    c. Hanford Engineering Development Laboratory
    d. Idaho National Engineering Laboratory
    e. Knolls Atomic Power Laboratory
    f. Energy Technology Engineering Center
4. Assistant Secretary for Fossil Energy.
    a. Bartlesville Energy Technology Center [2/]
    b. Grand Forks Energy Technology Center [2/]
    c. Laramie Energy Technology Center [2/]
    d. Morgantown Energy Technology Center [2/]
    e. Pittsburgh Energy Technology Center [2/]
    f. Carbondale Mining Technology Center [2/]
    g. Pittsburgh Mining Technology Center [2/]
5. Assistant Secretary, Conservation and Renewable Energy: Solar Energy Research Institute

[2/] Government-owned, Government-operated laboratory.

Vertical line denotes change.

## Department of Energy User Facilities

The Department of Energy national laboratories currently make available many of their facilities and scientific research instrumentation to university and other researchers. A partial list is attached.

The established Department of Energy criteria for designating user facilities at its national laboratories are as follows:

- The facilities involve a collection of interrelated equipment, software, and people which may have broad use in conducting important scientific and technological research and which do not compete with private capability; and

- The sponsoring agency ensures that sufficient time, space and other resources are made available to users without compromising the objectives of either the laboratory or the funding agency's research programs.

Once these criteria are met, other considerations are:

- The research capabilities of the facility are unique, or at least relatively rare, within the United States.

- Outside groups from industry, universities, and other research institutions have specifically expressed a desire to utilize the facility--often creating a formal group to make decisions on priorities.

- The facility is of sufficient monetary value and/or sophistication that widespread duplication is unlikely.

- Adequate support services are available on-site at the facility to allow an outside experimenter to complete all the essential elements of an experiment.

- A source of federal funding, independent of the user, is available to provide for routine maintenance and repair.

- The facility is located in an accessible area.

- The facility design is such that users can be readily accommodated to conduct experiments without health and safety risks or without risk of damage to the facility.

The guidelines for utilization of the Department's facilities, both for proprietary and non-proprietary work, are as follows:

> For nonproprietary use, it is expected that experimental results from the research and development done at DOE-funded facilities will be published in the open scientific literature. In those cases, there is no charge for using the machine if the research fits within the mission of the funding agency. This is true for [illegible]

Attachment 5

both industrial and university researchers. There are of course, charges made for computer time, machine shop time, and other services that are beyond the normal, designated use of the machine. Travel, salaries, etc., are expenses usually borne by the researcher's home institution.

Industries wishing to utilize a facility for proprietary purposes are charged for its use, usually in dollars per hour, which includes operating costs and appropriate depreciation charges. In addition, the user agreements set forth the terms and conditions for the use of facilities and, in particular, recognizes that proprietary data (i.e., trade secret data developed at private expense) of the user could be utilized in the work performed without the government taking unlimited rights to the proprietary data.

A recently approved Department of Energy action grants a class waiver of government rights for inventions that arise from the use of DOE facilities and facility contractors to third-party sponsors. The purpose of this class waiver is to provide patent rights whenever industry procures R&D and technical services or uses the facilities of the DOE national laboratories on a cost reimbursable basis.

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## User Facilities and Instrumentation

### Ames Laboratory

Coal Preparation and Characterization Facility
Material Preparation Center

### Argonne National Laboratory

4-MV Dynamitron Facility
Argonne Superconducting Heavy-Ion Linac
Tandem Accelerator Facility
Facility for High-Resolution Atomic Spectroscopy
Intense Pulsed Neutron Source I (IPNS-I)
Users Support Center
Biological-Materials Growth Facility
High Voltage Electron Microscope Tandem Facility

### Brookhaven National Laboratory

National Synchrotron Light Source
Alternating Gradient Synchrotron
Scanning Transmission Electron Microscopy Facility
PETT VI Positron Emission Transaxial Tomograph
JSW168 Small Cyclotron
60-Inch Cyclotron
Double MP Tandem Accelerator Facility

### Idaho National Engineering Laboratory

Hot Cell Facilities
Thermal Hydraulics Experimental Facility
Power Burst Facility Reactor
Advanced Test Reactor
Test and Evaluation Laboratory

### Lawrence Berkeley Laboratory

Bevalac
88-Inch Cyclotron
National Tritium Labeling Facility
The National Center for Electron Microscopy
SuperHILAC

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## Los Alamos National Laboratory

National Flow Cytometry and Sorting Research Resource
National Stable Isotopes Resource
Weapons Neutron Research Facility
Clinton P. Anderson Meson Physics Facility (LAMPF)
National Genetic Sequence Data Bank
Los Alamos National Environmental Research Park

## Oak Ridge National Laboratory

Oak Ridge National Environmental Research Park
Surface Modification and Characterization Facility
Neutron Scattering Facility
National Center for Small-Angle Scattering Research
Atomic Physics Low-Energy Multiply-Charged Ion Beams
Holified Heavy Ion Research Facility
Atomic Physics E-N Tandem Accelerator - 6 MV
Oak Ridge Electron Linear Accelerator
Shared Research Equipment (SHaRE Microanalysis Facility)
Health Physics Research Reactor

## Sandia National Laboratories

Combustion Research Facility (Livermore, Ca.)
Central Receiver Test Facility

## Fermi National Accelerator Laboratory

Fermilab High Energy Energy Accelerator
Fermilab Central Computation Center
Fermilab Multiparticle Spectrometer
Fermilab Tagged Photon Spectrometer
Neutrino Flux Monitoring Facility
Fermilab Bubble Chamber Facility
Meson Experimental Area
Neutrino Experimental Area
Proton Experimental Area

## Notre Dame Radiation Laboratory

Van de Graaff-ESR Spectrometer

Savannah River Laboratory

Aquatic Research Laboratory

Stanford Linear Accelerator Center

Positron-Electron Storage Ring (PEP)
Hybrid Facility
Spectrometer Facility
SPEAR Storage Ring
High Energy Particle Test Beams

Stanford Synchrotron Radiation Laboratory

Entire Facility

University of Rochester Biomedical Laboratory

Laboratory for Laser Energetics

Geothermal Test Facility (East Mesa, Ca.)

Entire Facility

- **Combustion Research Facility** - The Department of Energy has a Combustion Research Facility run by the Sandia National Laboratories at Livermore, California. It is used for sophisticated optical and analytical studies of flame processes (both laminar and turbulent) and detailed investigations of combustion processes in engines, power systems, boilers, and furnaces. Advanced laser-optical diagnostic techniques allow detailed measurements to be made in combustion environments. The lasers, in conjunction with optics and detectors, can be used to measure localized time-resolved species concentrations, temperatures, velocities, and turbulence levels within flames without disturbing the process and may furnish the keys to understanding the physical processes.

An advisory board provides independent counsel, and three of its seven members are from industry. The facility, which has been in operation for approximately one and one-half years, has received broad acceptance and use by industry. During the past year, about 150 visiting scientists have used the facility to pursue industry and university research programs with Sandia researchers.

Exxon, for example, in the studies of processes for removing nitrogen oxides from stacks by injecting ammonia, has worked successfully with Sandia staff in defining the chemical mechanisms which control this process and has developed a computer model which predicts the amount of ammonia and the conditions needed to remove nitrogen oxides. Exxon is developing a commercial process to utilize that knowledge.

A small company, R & P, Inc., which developed a unique real-time particle mass monitor for exhaust systems, needed data to provide operating limits on its analyses of emissions from stack gases. Those hard data were needed to give credibility to the process; and after having obtained the data from research done at the Sandia facility, R & P now has projects with TVA and EPRI.

Attachment 5

Engine combustion research at Sandia emphasizes the use of laser probes to measure the combustion processes in advanced engines. Research on direct-injection stratified charge combustion is being done in cooperation with General Motors and Princeton, Los Alamos, and Lawrence Livermore Laboratories. Similarly, dilute homogeneous charge is being looked at with Ford and Exxon as well as several university and private research teams. A third group is studying diesels with Cummins and International Harvester. Meeting twice a year, researchers in these goups have succeeded in providing industry with tools and insights that the industry claims have already contributed to advances in engine design.

Boiler manufacturers are participants also. Babcock and Wilcox, for example, has sent staff to the Combustion Facility to learn how to use these optical techniques for detailed measurements of combustion processes that involve soot formation, nitrogen chemistry, turbulent reacting flow, and droplet combustion. Even the process for utilization of wood chips is of interest to forest product companies, and they have conducted several experiments at Sandia on the combustion of wood particles to replace oil and gas.

Sandia research results are broadly distributed. In addition to normal publication channels, results are transmitted through cooperative working groups with industry, visiting scientist exchanges, and short courses which are offered to U.S. and foreign combustion researchers from industry, other governmental laboratories, and universities.

- **National Synchrotron Light Source** - A National Synchrotron Light Source has recently been completed at Brookhaven National Laboratory. The purpose is to provide a unique facility to users from throughout the country for continuum x-ray and vacuum ultraviolet sources. The facility has room for more than 40 experiments; has two storage rings; and was designed in cooperation with national laboratories, universities, and industrial laboratories to be amenable to general usage in the number of beam lines and their flexibility. Participating research teams have been set up; and they have invested expertise, funds, and/or instrumentation (including monochromators, target chambers, mirrors/gratings/crystals, detectors, etc.) for specific beam lines. In addition, the cumulative funding by participants for the beams is substantial. The capital investment by industry is approximately $7.3 million, by universities is $6 million, and by the government is $5.8 million. Usage of such beam lines by industry is also projected to be very large with the leading R&D industrial research teams (including Bell Laboratories, IBM, Xerox, Exxon, Gulf, Ashland) are already participating in the activity. In fact, the Executive Committee, which is responsible for policy and priority decisions on use of the light source, has as its chairman a person from industry and one-third of its membership comes from industry.

The National Synchroton Light Source is a very large step toward the utilization of ultraviolet and x-ray radiation for disciplines that include advanced, very small-scale electronic device fabrication (x-ray lithography); surface and condensed matter sciences; biophysics; and chemistry. Experiments such as biological beam lines to look at the effects of different wavelengths of radiation on human cell mutation, transformation, and mortality as well as wavelength-dependent fluorescent spectra for highly specific cell component separation have great potential in the health areas. They demonstrate the ability to do, in the physical sciences, trace element analysis by x-ray and fluorescence absorption to enable parts per million sensitivity in spaces as small as one micrometer. The flux enables detailed studies of surface structures and phase transitions, even of low scattering substances such as hydrocarbons. The structure for small metal clusters of catalytic interest is observable.

Mr. VOLKMER [presiding]. Thank you very much.

We will wait for all three witnesses to finish their statements and then go to questions.

We will now hear from Dr. Bennett.

## STATEMENT OF IVAN L. BENNETT, VICE CHAIRMAN, ENERGY RESEARCH ADVISORY BOARD, AND CHAIRMAN, ERAB MULTIPROGRAM LABORATORY PANEL

Mr. BENNETT. Mr. Chairman, it is a pleasure and an honor for me to appear before the Subcommittees on Energy Development and Applications and Energy Research and Production to discuss the findings and recommendations of the Energy Research Advisory Board report on the Department of Energy Multiprogram Laboratories.

Mr. Louis H. Roddis, Jr., Chairman of ERAB, regrets that he could not be present today. He asked me to meet with you both as Vice Chairman of ERAB and as Chairman of the Multiprogram Laboratory Panel.

The ERAB is an independent science and technology committee appointed by the Secretary of Energy to advise the Department of Energy. Operating under the provisions of the Federal Advisory Committee Act, the Board reports to the Secretary and Deputy Secretary. All of its studies are carried out explicitly at their request.

ERAB's role is solely advisory. It reflects the perspectives of a diverse group of private citizens, scientists, lawyers, economists, and engineers, who are knowledgeable about energy technologies, but who do not make policy or implementing decisions for the Government.

In discussing the Multiprogram Laboratory report with you, I am speaking for ERAB and not for the Department or the administration.

The full report is appended to my formal testimony. It consists of three volumes: The first contains the panel's findings and recommendations; the second, staff studies provided to the panel by Oak Ridge National Laboratory; the third, DOE papers and orders relating to the laboratories.

I should like to state at the outset that it was a rare privilege to chair a group with such clear determination to arrive at fair and objective conclusions and recommendations.

Our panel represented a balanced diversity of viewpoints. Of equal importance, it was composed of individuals who were prepared to and did devote a great deal of personal effort toward fulfilling the charge to the board by the Deputy Secretary of Energy.

This was a truly distinguished group; the Board is very appreciative of their efforts. As is customary, they served without pay.

I must further state in preface that the panel benefited immeasurably from the full and candid cooperation of the DOE headquarters and operation office staffs and the laboratory directors and their staffs.

Additionally, the panel's deliberations were aided significantly by the insightful views provided by many representatives of the private R&D sector.

Our meetings were open to and well attended by the public. The panel submitted its report to ERAB for approval in a public meeting; on September 10, it was adopted, after input from the Board, as an ERAB report to the Department.

Lastly, I want to reiterate the statement that our findings and recommendations were arrived at independently and do not necessarily coincide with the views of the Department or the administration .

In order to give credit where credit is due, let me briefly describe the process that led to the Multiprogram Laboratory report. When Deputy Secretary Davis first met with ERAB, he expressed a concern about the problem of maintaining the vitality of the Multiprogram Laboratories through the present period of budgetary stringency.

In further conversations with the Chairman of ERAB, the idea of having ERAB examine the situation emerged, resulting in his request on September 29, 1981, defining the issues to be explored and the scope of the study.

Responding to the Department's request was clearly a more demanding task than we could undertake in our regular meeting. Consequently, the Chairman of ERAB established the panel to undertake a detailed factfinding exploration of the issues.

A significant point is that this and all our other panels report to ERAB and not to the Department. The members are appointed by the ERAB Chairman and staff support is arranged by the staff that regularly assists ERAB.

The panel membership was chosen to include individuals with extensive experience in R&D management and administration in private industry, government and universities. Several ERAB members also served on the panel.

A list of members appears at the beginning of the report. These people have managed or been involved with oversight of research and technology laboratories and have been or are in major positions of responsibility in the Nation's science and engineering community—including one DOE laboratory director, the presidents of the Electric Power Research Institute and Gas Research Institute, and the executive director of the American Association for the Advancement of Science.

After a series of intensive briefings and meetings, the panel provided an interim report in March 1982 addressing the roles and missions of the laboratories, which ERAB adopted and submitted to the Department.

Subsequently, subgroups of the panel visited each of the nine laboratories under examination—meeting with staff, the laboratory director and cognizant DOE field officials. From these visits emerged much of the knowledge and insight on which the panel report is based.

In addition, a number of staff studies were commissioned by DOE to provide a consistent data base and a perspective on such matters as how national laboratories function in other countries and the past achievements and accomplishments of the labs.

Finally, the panel's report was reviewed and then discussed at length by the full Board in an open meeting September 9 and 10, 1982; after some minor changes, it was unanimously adopted.

Thus, although the substance of the report reflects months of intensive effort by the members of the panel, it has become an ERAB report with the full endorsement of the Board. This does not mean that there were no areas of disagreement.

Rather, it is the nature of such a process that the clash of disparate viewpoints serves to illuminate difficult issues and to clarify points of controversy so that a common ground of agreement can be found.

I do not plan to review each and every recommendation in the report. Some, such as that recommending that the laboratories continue to carry out core elements of the Department's "national trust" fundamental research missions in the physical and radiobiological sciences, are noncontroversial.

Perhaps the most significant of the panel's findings is that the scientific and technological capabilities of the laboratories can contribute significantly to meeting national needs for increased innovation, productivity, and international competitiveness.

The use of these capabilities for these purposes seems to us to be justified because they were developed to their high degree of sophistication at public expense over several decades.

The panel has three recommendations in this connection. One is to allow the laboratories to do more reimbursable work for others—that is, other Federal agencies, State and local governments, and industry—by relaxing constraints on such work.

Another is to permit and encourage joint ventures in selected projects with industry, including test and pilot demonstrations, in order to assist industry with tests of economic feasibility and shorten the time lag for technology transfer to the private sector.

The third is to allow the laboratories to work more closely with industry in areas of special laboratory expertise and capability by such means as responding to requests for proposals from industry cooperative groups, for example, the Electric Power Research Institute. And to work in partnership with industry or as subcontractors to meet technical needs of Federal agencies.

All of these recommendations are pointed toward appying the full complement of national scientific and technical expertise to problems of national interest.

Clearly, the relaxation of constraints on work for others must not interfere with the primary energy mission of the labs.

The panel is fully cognizant that the laboratories must participate fairly if they are perceived as vying with the private sector for Government work. Costing of laboratory work for these purposes therefore must be calculated as nearly as possible on the same bases as in industry. Nevertheless, greater accessibility by others to the laboratories, within reasonable limits, would represent prudent use of these important institutions.

All of the foregoing presumes a departmental organizational and management structure consistent with more nearly optimal utilization of the scientific and technical capabilities of the laboratory complex.

In point of fact, the panel found that even in the absence of the proposed roles, layering and fractionation of managerial and research and development responsibilities in DOE requires the laboratories to interact with DOE on an excessive number of horizontal and vertical levels and with heavy reliance on individual negotiations.

As a consequence, the Department's central management has little control over laboratory activities except through gross budget actions at highly aggregated program levels.

For the same reasons, the laboratory directors have relatively little control over the research and development activities in their own laboratories. The totality of each laboratory's program is primarily the result of multiple negotiations between numerous program offices at headquarters and the laboratories at individual staff levels rather than at management levels.

In these circumstances, it is easy for the laboratories to lose their sense of overall basic mission and thus to enter into fields not appropriate to their roles or capabilities.

To alleviate these conditions, the panel recommends that DOE designate a high level official, such as a Deputy Under Secretary, whose sole function is to be the chief laboratory executive with authority to help determine and defend the research and development budget, to allocate the resources, to decide where work is to be done, and to assess laboratory scientific, technical and managerial performance on a regular basis.

A related recommendation urges support of rolling 2-year appropriations by Congress for research and development with carryover funding to stabilize agency and laboratory planning and program execution.

As an aside, the panel found that the laboratories were required, unnecessarily, we believe, to divert resources from their research and development missions to accommodate grossly excessive paperwork requirements.

One laboratory, for example, is required to be responsive to 137 different DOE orders and policy issuances and receives its funding through 129 separate accounts which require separate controls and reporting mechanisms.

The panel strongly recommends that the Department utilize the services of an outside audit contractor familiar with both Government and industry practices to conduct a thorough audit of paperwork requirements in the headquarters/operations office/laboratory chain of command.

The panel also found that measures could be taken by which DOE could make better use of the laboratories for its direct mission purposes. For example, the laboratories constitute an exceptional reserve of scientific and technical knowledge and expertise.

However, the Department makes little or no formal use of this capability in its research and development policy and planning. Participation by the laboratories in a consultative capacity in these respects would add an invaluable knowledge dimension to the Department's resources for these planning purposes.

Similarly, the panel finds that the Department's research and development program planning does not consider adequately end user views.

The panel recommends that user groups reporting to the Department be established, similar to the High Energy Physics Advisory Panel and the Nuclear Science Advisory Committee, for all of the Department's major mission programs and facilities.

The panel also concluded that some flexibility should be provided to the laboratories to maintain and develop their expertise on a continuing basis at the emerging forefront areas of science and technology.

This is required if the laboratories are to best serve the Department's and the Nation's present and future interests.

The panel therefore recommends that each laboratory be premitted to use 1 to 2 percent of its capital and operating budget for independent research and development at the discretion of the laboratory director in order to enrich its research capabilities.

As I am sure the subcommittees are well aware, there is widespread concern about the state of education and training in this country in terms of meeting our present and future requirements for qualified scientists and engineers.

Traditionally, the laboratories have cooperated with universities in education and training by providing opportunities for onsite participation of faculty and students in laboratory programs and in using laboratory facilities.

In most laboratories as much as 20 percent of the full-time equivalent staff is composed of visiting faculty and graduate students.

The panel believes the laboratories make a unique and important contribution in this area and urges that the Department continue to support laboratory and university cooperation in the training of scientists and engineers.

Having pointed out certain deficiencies in the Department's management of the laboratories and suggested areas needing improvement, the panel nevertheless took particular note that in many respects the Department has made important strides.

For example, the appraisal of laboratory performance has been somewhat loosely implemented in recent years; however, the ongoing effort to develop a departmentwide systemized and codified appraisal procedure with appropriate management followup, when completed and implemented, should result in benefits to both the Department and the laboratories .

The implementation and gradual maturation over the past few years of the laboratory institutional planning process also has been a beneficial initiative in that it offers some degree of desirable long-range research and development program planning at the laboratories.

Also, the recently issued class waiver of patent rights in the case of fully cost reimbursed private use of laboratory facilities will be a significant advance, if it is vigorously pursued at the operations office level.

Moreover, the recent DOE order on technology transfer at least establishes this function as a formal part of the Department and laboratory mission, albeit no dedicated funding has yet been forthcoming. Such support will be necessary if the technology transfer function is to become fully operational.

In concluding, let me state that the panel finds both the scientific and technological capabilities of the laboratories and the qualities and resourcefulness of laboratory leadership to be impressive. We hope our efforts will contribute toward more effective use of this outstanding research and development asset in the Department's and the Nation's interest.

This concludes my statement. I will be glad to respond to questions.

Mr. VOLKMER. Thank you very much, Dr. Bennett.

[The prepared statement of Mr. Bennett follows:]

### TESTIMONY OF IVAN L. BENNETT, VICE CHAIRMAN, ENERGY RESEARCH ADVISORY BOARD AND CHAIRMAN, ERAB MULTIPROGRAM LABORATORY PANEL

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All of the foregoing presumes a departmental organizational and management structure consistent with more nearly optimal utilization of the scientific and technical capabilities of the laboratory complex. In point of fact, the panel found that even in the absence of the proposed rules, layering and fractionation of managerial and research and development responsibilities in DOE requires the laboratories to interact with DOE on an excessive number of horizontal and vertical levels and with heavy reliance on individual negotiations. As a consequence, the department's central management has little control over laboratory activities except through gross budget actions at highly aggregated program levels.

For the same reasons, the laboratory directors have relatively little control over the research and development activities in their own laboratories. The totality of each laboratory's program is primarily the result of multiple negotiations between numerous program offices at headquarters and the laboratories at individual staff levels rather than at management levels. In these circumstances, it is easy for the laboratories to lose their sense of overall basic mission and thus to enter into fields not appropriate to their roles and capabilities.

To alleviate these conditions, the panel recommends that DOE designate a high level official, such as a deputy under secretary, whose sole function is to be the chief laboratory executive with authority to help determine and defend the research and development budget, to allocate the resources, to decide where work is to be done, and to assess laboratory scientific, technical and managerial performance on a regular basis. A related recommendation urges support of rolling two-year appropriations by Congress for research and development with carry over funding to stabilize agency and laboratory planning and program execution.

As an aside, the panel found that the laboratories were required, unnecessarily we believe, to divert resources from their research and development missions to accommodate grossly excessive paperwork requirements. One laboratory, for example, is required to be responsive to 137 different DOE orders and policy issuances and recieves its funding through 129 separate accounts which require separate controls and reporting mechanisms. The panel strongly recommends that the department utilize the services of an outside audit contractor familiar with both Government and industry practices to conduct a thorough audit of paperwork requirements in the headquarters/operations office/laboratory chain of command.

The panel also found that measures could be taken by which DOE could make better use of the laboratories for its direct mission purposes. For example, the laboratories constitute an exceptional reserve of scientific and technical knowledge and expertise. However, the department makes little or no formal use of this capability in its research and development policy and planning. Participation by the laboratories in a consultative capacity in these respects would add an invaluable knowledge dimension to the department's resources for these planning purposes.

Similarly, the panel finds that the department's research and development program planning does not consider adequately end user views. The panel recommends that user group reporting to the department be established, similar to the high energy physics advisory panel and the nuclear science advisory committee, for all of the department's major mission programs and facilities.

The panel also concluded that some flexibility should be provided to the laboratories to maintain and develop their expertise on a continuing basis at the emerging forefront areas of science and technology. This is required if the laboratories are to best serve the department's and the Nation's present and future interests. The panel therefore recommends that each laboratory be permitted to use 1 to 2 percent of its capital and operating budget for independent research and development at the discretion of the laboratory director in order to enrich its research capabilities.

As I'm sure the subcommittees are well aware, there is widespread concern about the state of education and training in this country in terms of meeting our present and future requirements for qualified scientists and engineers. Traditionally, the laboratories have cooperated with universities in education and training by providing opportunities for onsite participation of faculty and students in laboratory programs and in using laboratory facilities. In most laboratories as much as 20 percent for the fulltime equivalent staff is composed of visiting faculty and graduate students. The panel believes the laboratories make a unique and important contribution in this area and urges that the department continue to support laboratory and university cooperation in the training of scientists and engineers.

Having pointed out certain deficiencies in the department's management of the laboratories and suggested areas needing improvement, the panel nevertheless took particular note that in many respects the department has made important strides. For example, the appraisal of laboratory performance has been somewhat loosely implemented in recent years; however, the ongoing effort to develop a departmentwide systemized and codified appraisal procedure with appropriate management follow-up, when completed and implemented, should result in benefits to both the department and the laboratories.

The implementation and gradual maturation over the past few years of the laboratory institutional planning process also has been a beneficial initiative in that it offers some degree of desirable long-range research and development program planning at the laboratories. Also, the recently issued class waiver of patent rights in the case of fully cost reimbursed private use of laboratory facilities will be a significant advance, if it is vigorously pursued at the operations office level. Moreover, the recent DOE order on technology transfer at least establishes this function as a formal part of the department and laboratory mission, albeit no dedicated funding has yet been forthcoming. Such support will be necessary if the technology transfer function is to become fully operational.

In concluding, let me share that the panel finds both the scientific and technology capabilities of the laboratories and the qualities and resourcefulness of laboratory leadership to be impressive. We hope our efforts will contribute toward more effective use of this outstanding research and development asset in the department's and the nation's interest. This concludes my statement. I will be glad to respond to questions.

RÉSUMÉ OF IVAN L. BENNETT, JR.

*Born:* Washington, D.C., March 4, 1922.

*Married:* Martha Rhodes, 1944; 4 children.

*Education:* Emory University, A.B. 1943; M.D. 1946; University of South Carolina, Honorary L.H.D. 1981.

Post Graduate Residency Training: Emory University; Duke University; Johns Hopkins University; and Diplomate in Internal Medicine, 1954.

*Military Service:* Lt. jg, M.C. USNR, U.S. Naval Medical Research Institute, Bethesda, Md., 1947-49.

*Positions Held:* Assistant Professor of Internal Medicine, Yale, 1952-54; Associate Professor of Medicine; Professor of Medicine; Professor of Pathology, Johns Hopkins University, 1954-69; Pathologist-in-chief, Johns Hopkins University, 1958-69; Deputy Director and Acting Director, OSTP, Office of the President 1966-69; Vice President and Executive Vice President for Health Affairs, New York University; 1969-82; Dean, NYU School of Medicine 1970-1982; Acting President, NYU 1979-82; and Professor of Medicine, NYU 1970-Present.

*Membership:* Approximately 50 professional and honorary societies: President, Science Advisory Committee; Member 1966-70; consultant-at-large 1970-72; National Board of Medical Examiners 1966-68; UN Secretary General's Study Group on Chemical and Biological Warfare 1969; Chairman of the US-Japan Cooperative Medical Science Program 1972; Charter member, Institute of Medicine; Life Sciences Advisory Committee of NASA 1971-73; President's Committee on National Medal of Science 1970-74; Consultant, NSC 1973-77; Director's Advisory Committee NIH 1978-81; Chairman, Association of American Medical Colleges 1976; Defense Science Board, DOD 1972-present; and Vice Chairman Energy Research Advisory Board DOE 1980-present.

*Author:* 200 scientific and technical papers; and "Principles of Internal Medicine" Editions 3, 4, 5, 6.

Mr. VOLKMER. We will now hear from Dr. Pry. You may proceed with your statement.

## STATEMENT OF ROBERT H. PRY, EXECUTIVE VICE PRESIDENT—TECHNOLOGY, GOULD, INC.

Mr. PRY. Thank you, Mr. Chairman.

I want to thank you for the opportunity to appear before you today. My name is Robert Pry, and I am executive vice president for Gould Technology Inc., a major producer of electronic and electrical equipment with annual sales of over $2 billion.

Our headquarters are just north of Chicago in Rolling Meadows, Ill.

Gould has engaged in major joint development programs with the Department of Energy in the recent past. I personally have been connected with joint development activities between industry and DOE/AEC for almost 30 years. Recently I have participated in a DOE Energy Research Advisory Board study of the role of the DOE National Laboratories. I am also co-chairman of an Industrial Research Institute Subcommittee on Industry/National Laboratories Interaction, which was formed to better understand and stimulate interaction between our National Laboratories and U.S. business, large and small. This committee is composed of industrial R&D vice presidents and National Laboratory directors.

The Industrial Research Institute is an organization whose active membership consists of research and development vice presidents of most of the Nation's major corporations. Its purpose is to promote the understanding and progress of the industrial research and development process.

Notwithstanding these relationships, past and present, it should be understood that the testimony I am about to give does not represent the position of any of these named organizations, but is a representation of my own views based upon, among other things, these associations.

Before summarizing my views briefly, I would like to ask the committee to enter into the record as part of my extended written testimony, an article recently sponsored by the Subcommittee for Industry/National Laboratories Interactions of the Industrial Research Institute, and published in a recent issue of the Institute's journal "Research Management". Although this article does not represent any official position of IRI, it does represent a thoughtful and widely accepted view of some of the roadblocks to technology transfer from the government to the private sector and how they might be alleviated, as well as some positive suggestions related to when and how the DOE laboratories might best be utilized in the national interest in nondefense areas.

Incidentally, since that time we published an additional article on National Laboratories on the use of these excellent facilities.

In approaching the subject of DOE research and development and technology transfer to the private sector, I would like to stress that there is, more often than not, a congruence of purpose between forwarding national interest and private interest. In fact, as we look at the questions of: (a) the best use of the National Laboratories and private industry research and development; (b) a constructive patent policy for stimulating innovation; and (c) incentives for technology transfer and exploitation, and focus on how to bring the Nation's science and technology most rapidly to bear on the national strategic issues of energy self-sufficiency and indeed abundance, then many of the problems that have been discussed in the past related to equity between industry on the one hand and private taxpayers on the other become nonissues.

For example, if we consider equity for all parties, all things considered, including rapid and efficient use of the technology in the United States, then patent exclusivity or special arrangement to provide incentives to industry becomes rather a means to obtain overall equity to all our citizens rather than providing special privilege with taxpayer's money.

Let me be specific, calling largely upon the report which has been entered into the record.

## I. FOR BEST TRANSFER OF TECHNOLOGY INTENDED FOR EXPLOITATION

A. The system for allocating projects among labs and industry should be revised so as to avoid unnecessary creation of the need to transfer technology, one of the most difficult operations in any scientific endeavor.

Development of technology intended for the market in the first instance should be assigned to the labs only when they possess special capabilities. As a means of determining whether these capabilities exist and where. Industry and the labs should both be allowed to respond to DOE requests for proposals, independently and jointly.

2. Their responses should be evaluated in a peer review system that weighs both the technical merit of proposals and the likeli-

hood that the proposal including the location of the work will lead to a successful transfer to commercialization.

B. In order to increase the likelihood of transfer, lab projects should be contingent upon industry's interest once technical feasibility has been established.

First, industry's willingness to share costs should be taken as a principal measure of such interest. Lab industry interactions at this stage should take the form of collaborative efforts, joint programs, industry working with the labs, lab programs and people working within the lab. Parenthetically, we should not be fooled into believing that the DOE laboratory function is finished when technical feasibility has been demonstrated. The next step of transfer of that technology to industry is the most important and the most difficult of any laboratory function, public or private.

DOE should help induce industry to share costs by granting rights on the results of projects, keeping the extent of industry's contribution and the risks associated with an attempt at exploitation in mind.

## II. TO TRANSFER TECHNOLOGY FROM THE LABS FOR SPIN-OFF APPLICATIONS, WHERE SMALL BUSINESSES CAN PLAY A MAJOR ROLE

A. Intimate interaction between industry and lab scientists should be promoted and efforts should be undertaken to more widely publicize lab spinoff type results as well as lab science results in general.

B. The labs should be induced to act in effect as entrepreneurial suppliers of goods and services—in this case exploitable lab results.

First, lab management should provide incentives to lab scientists to seek out spinoffs.

Second, DOE should fund programs designed to transfer lab technologies to spinoff applications.

Third, DOE policy should be modified to make it easier for labs to work for industry—particularly small businesses—for this purpose.

C. Spinoff firms should be nurtured including those started by ex lab employees.

D. DOE patent policy should be altered to provide exclusive rights to large as well as small business when the requirements of commercialization warrant granting such rights to large firms including the large amount of moneys that may be necessary.

I have not had time to go into detail with respect to each of these issues. They are dealt with in more detail in the written version and the Industrial Research Institute article. I commend those more detailed recommendations to you for your consideration.

Our National Laboratories are a great resource for progress in this country if we can find better ways to make them and the results of their endeavors at least as accessible, hopefully more accessible, to U.S. industry than to those of other countries. I have tried briefly to point to needed emphasis in several areas to help bring this about.

First, action to stimulate more person-to-person interaction between large industry or small business technical personnel and National Laboratory personnel on a one-to-one basis. One of the things that I like to point out that just as in boxing and football, the essence of the sport is body contact. So in technology transfer, in a similar way, it is mind contact that make the difference.

Second, action to encourage—rather than restrain—National Laboratories to advertise and promote the results that may lead to commercializable products or processes.

I was very interested to see Madam Chairman mention, for example, the excellent results of the laboratory in achieving a half a dozen IR-100 awards from the Industrial Research Institute magazine. Unfortunately, when I attended that meeting in Chicago where these awards were given out—which was attended, incidentally, by over 100 executives of major companies in the United States—the National Laboratories had been required previously to take away their exhibits and not show them by order from the adminstration. I think that is very discouraging.

Third, action to make sure that the liberalization of the patent policies of DOE is in fact followed up by simple regulations and practices positively pursued by DOE which provide the needed incentives to the private sector in the United States to utilize National Laboratory know how as a basis for private patents, so that the private sector will exploit such patents for their benefit and that of the public at large.

I stand ready to help in any way I can to bring this about and to answer any questions you might have concerning my remarks.

Thank you.

[The prepared statement of Mr. Pry follows:]

### TESTIMONY OF DR. ROBERT H. PRY, EXECUTIVE VICE PRESIDENT—TECHNOLOGY, GOULD INC.

Mr. Chairman, Mrs. Chairperson, and Members of the Committee: Gould has engaged in major joint development programs with the Department of Energy in the recent past. I personally have been connected with joint development activities between industry and DOE/AEC for almost 30 years. Recently I have participated in a DOE Energy Research Advisory Board study of the role of the DOE National Laboratories. I am also co-chairman of an Industrial Research Institute subcommittee on Industry/National Laboratories interaction, which was formed to better understand and stimulate interaction between our National Laboratories and U.S. business, large and small. This committee is composed of Industrial R & D Vice Presidents and National Laboratory Directors. The Industrial Research Institute is an organization whose active membership consists of Research and Development Vice Presidents of most of the nation's major corporations. Its purpose is to promote the understanding and progress of the industrial research and development process.

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In approaching the subject of DOE research and development and technology transfer to the private sector, I would like to stress that there is, more often than not, a congruence of purpose between forwarding national interest and private interest. In fact, as we look at the questions of best use of the National Laboratories and private industry research and development, a constructive patent policy for stimulating innovation, incentives for technology transfer and expolitation, and focus on how to bring the nation's science and technology most rapidly to bear on the national strategic issues of energy self sufficiency and indeed abundance, then many of the problems that have been discussed in the past related to equity between industry on the one hand and private taxpayers on the other become non issues.

For example, if we consider equity for all parties, all things considered, including rapid and efficient use of the technology in the U.S., then patent exclusivity or special arrangement to provide incentives to industry becomes rather a means to obtain overall equity to all our citizens rather than providing special privilege with taxpayer's money.

Let me be specific, calling largely upon the report which has been entered into the record.

*First, for best transfer of technology intended for exploitation.*

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industry and the labs should both be allowed to respond to DOE requests for proposals, independently and jointly

Their responses should be evaluated in a peer review system that weighs both the technical merit of proposals *and* the likelihood that the proposal including the location of the work will lead to a successful transfer to commercialization.

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DOE should help induce industry to share costs by granting rights on the results of projects, keeping the extent of industry's contribution *and* the risks associated with an attempt at exploitation in mind.

*Second, to transfer technology from the labs for spinoff applications, where small businesses can play a major role.*

Intimate interaction between industry and lab scientists should be promoted and efforts should be undertaken to more widely publicize lab spinoff type results as well as lab science results in general.

The labs should be induced to act in effect as entrepreneurial suppliers of goods and services (in this case exploitable lab results).

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DOE policy should be modified to make it easier for labs to work *for* industry (particularly small businesses) for this purpose.

Spinoff firms should be nurtured including those started by ex lab employees.

DOE patent policy should be altered to provide exclusive rights to large as well as small business when the requirements of commercialization warrant granting such rights to large firms. Including the large amount of monies that may be necessary.

I have not had time to go into detail with respect to each of these issues. They are dealt with in more detail in the written version and the Industrial Research Institute article. I commend those more detailed recommendations to you for your consideration.

Our National Laboratories are a great resource for progress in this country *if* we can find better ways to make them and the results of their endeavors at least as accessible, hopefully more accessible, to U.S. industry than to those of other countries. I have tried briefly to point ot needed emphasis in several areas to help bring this about.

Action to stimulate more person to person interaction between large industry or small business technical personnel and National Laboratory personnel on a one to one basis.

Action to encourage (rather than restrain) National Laboratories to advertise and promote the results that may lead to commercializable products or processes.

Action to make sure that the liberalization of the patent policies of DOE is in fact followed up by simple regulations and practices positively pursued by DOE which provide the needed incentives to the private sector in the U.S. to utilize National Laboratory know how as a basis for private patents, so that the private sector will exploit such patents for their benefit and that of the public at large.

I stand ready to help in any way I can to bring this about and to answer any questions you might have concerning my remarks.

# Problems and Opportunities in Technology Transfer from the National Laboratories to Industry

**Joseph Morone and Richard Ivins**

*Government, the national labs and industry must make changes if there is to be effective transfer of technology from the government labs to industry.*

Even the most cursory examination of technology transfer reveals enormous variety. The technologies can be products, materials, production techniques, software, test facilities, and expertise. The means by which they are transferred range from joint industry-lab development projects, to education and consulting arrangements, to the formation of spinoff firms. The problems associated with their transfer range from patent and licensing problems, to industry ignorance of the technologies available at the labs and lab ignorance of the market conditions that govern the use of technologies, to the procedures by which government funded R&D projects are assigned to labs and industry.

Two broad classes of technology transfer emerge from this variety. There is the transfer of lab developed technologies to industry for applications different than those for which they were originally developed (spinoff applications), and there is transfer to the industrial applications for which the technologies were originally developed. The problems associated with each class, and the means for overcoming them, differ.

Transfer of technologies to spinoff applications emerged as a subject of national concern in the late 1950s and early 1960s. The issue then was whether technologies developed by NASA for the federal government could be usefully applied by industry and by state and local governments to purposes other than the nation's aerospace needs. The same issue arises in connection with technologies developed by DOE's labs: can the technologies developed by the labs in carrying out their missions be applied outside the labs to different purposes than those for which they were originally developed?

Many such transfers have occurred in the past. For example, semiconductor technology developed by Lawrence Berkeley Lab for its high energy physics experiments is "now used in medical diagnostic arrays, photo-diodes, infrared light detectors, oil well logging, radioactive dating, and scanning electron microscopy" (*1*). Similarly, a process for separating rare earth metals developed by Ames Lab in its basic research program is now employed widely in industry. Rare earth compounds separated by this process are used in applications ranging from the production of lasers, to the manufacture of television sets, to the refining of petroleum (*2*).

Transfer of technologies to intended market applications has been common in two periods of the labs' history — the first in the 1950s and early 1960s, when the technology intended for the market was nuclear reactor technology, the second in the 1970s and early 1980s, when the technologies intended for the market were alternative energy technologies, such as solar and fossil.

The transfer of nuclear reactor technology began in the early 1950s. At that time, most of the world's nuclear reactor expertise was sequestered at na-

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Joseph Morone, who holds a Ph.D. in Political Science from Yale University, is a member of the Technology Evaluation Operation at the General Electric Company's Research and Development Center. His major research area is the politics of science and technology. He is preparing a book on the decision making process in the development of nuclear power. Richard Ivins directs an effort at Argonne National Laboratory to improve interactions with industry and to promote technology transfer. Successively, he conducted and managed research and engineering programs in nuclear reactor safety, managed the high temperature battery development project, and directed the fossil technology programs at Argonne. He is a member of the Chicago Mayor's Task Force on High Technology Development. Mr. Ivins has a Master's degree in Chemical Engineering from Northwestern University and an MBA from the University of Chicago Executive Program.

tional labs for reasons of national security. During the decade that followed, a steady flow of people, ideas, and technology between the labs and industry took place. The labs trained industry scientists and engineers, lab scientists and engineers joined industry, the labs made available to industry detailed information about the various reactor types they had investigated, and they provided industry with substantial amounts of technical advice and supporting R&D. By the mid 1960s, the transfer of reactor technology had been accomplished. Today, with the wisdom of hindsight, many observers find fault with the ways in which the AEC promoted the nuclear industry's development. But most agree that at least with respect to technology transfer, the AEC succeeded. In one decade, it moved to the marketplace a new and complex technology that had originated in and had been developed by the national labs.

The second era of transfer of technologies intended for the market began in the mid and late 1970s when the labs were assigned major roles in the development of alternative energy technologies. For example, Argonne worked on high temperature batteries and on solar collectors, Berkeley worked on extracting hydrocarbon from plants and on developing solid state ballast for gas discharge lamps, Oak Ridge on energy efficient consumer products, Pacific Northwest on wind energy, and Sandia on instrumentation for geothermal, oil, and gas wells. Unfortunately, the government has been unable to establish with the alternative energy technologies the kind of relationship and flow of technology between labs and industry that existed in the nuclear era. We shall discuss the reasons for this later.

**Transfer To Spinoff Applications**

*Identifying Market Applications.* — The first obstacle in transferring technologies to spinoff applications is to identify the applications. This requires an unusual form of inventiveness. At any one time, a large and ill defined set of technologies or solutions are available at the labs. Simultaneously, an even larger and more poorly defined set of problems and opportunities are "available" in industry. The invention is linking an available solution with an available problem. In principle, this link is made either by industry seeking solutions for its problems, or by labs seeking problems for their solutions.

The key to linking lab technologies with industry problems is to identify similarities between the problems for which the technologies were developed by the labs and problems outside the labs to which the technologies might be applied. Consider the heat pipe, a passive device for transferring heat over long distances (up to tens of meters). In the 1960s, as part of its Space Nuclear Propulsion Program, Los Alamos advanced the development of heat pipes. Now the device is applied outside the lab in a variety of contexts, most of which are very different from space propulsion, but all of which have more or less similar heat transfer requirements. For example, it is used in the Alaskan oil pipeline to stabilize the ground below the pipeline's support piles by preventing thawing of the permafrost (*3*). The transfer to the aircraft industry of Hastelloy (alloy N), a material developed by Oak Ridge for its Molten Salt Reactor, provides another example. In both reactors and jet engines, this alloy satisfied the need for a material that would withstand high temperatures and highly corrosive environments (*4*).

*About This Article*

This article was prepared at the request of an Industrial Research Institute Task Force that is examining relations between industry and the Department of Energy's National Laboratories. The Task Force is comprised of representatives from IRI's Federal Science and Technology Committee and from the Department of Energy's Multiprogram Labs. It has concluded that IRI should promote greater communication between its members and the labs. This article is a first step toward that end. It is not, however, a policy statement of IRI or the Task Force. Its purpose is to stimulate discussion between industry and the labs about the most important form of industry-lab interaction — technology transfer.

In order to identify similarities, people at the labs who are familiar with the problems for which their technologies were developed must be made aware of similar kinds of problems in industry, and vice versa. This is not an overwhelming obstacle if the problem for which the lab developed a technology is an obviously generic one, as was the case with the heat pipe, or if the people who worked on the problem at the lab are in the same discipline as the people working on similar problems in industry, as was probably the case with Hastelloy (alloy N). But for problems that are less obviously generic, or when disciplinary boundaries have to be crossed, identifying similarities becomes far more difficult. At one time an attempt was made to use rocket fuel binder developed at NASA's Jet Propulsion Lab as road patching material (*5*). The similarities were identified successfully in this case (although the attempted transfer failed), but the likelihood of identifying such distant uses of lab technologies is small. The question that nags students of technology transfer is whether there are many other distant potential applications that remain unrecognized.

An obvious way to improve the likelihood of identifying problems in industry similar to those in the labs is to promote interactions between industry and the labs. The interactions should be as extensive and as technical as possible. Scientists and engineers with detailed knowledge of the lab's technologies and of the problems to which they are

*National Laboratory Task Force Member Laboratories*

| Laboratory | Technology Transfer Contact | Address |
|---|---|---|
| Ames | D. Williams | Ames Laboratory, Iowa State University<br>Ames, Iowa 50011 |
| Argonne | B.C. Huguelet | Argonne National Laboratory<br>9700 South Cass Avenue<br>Argonne, Illinois 60439 |
| Berkeley | R.J. Morris | Lawrence Berkeley Laboratory<br>One Cyclotron Road<br>Berkeley, California 94720 |
| Brookhaven | J. Hudis | Brookhaven National Laboratory<br>Upton, New York 11973 |
| Livermore | G.T. Richards | Lawrence Livermore Laboratory<br>P.O. Box 808<br>Livermore, California 94550 |
| Los Alamos | E.A. Stark | Los Alamos Scientific Laboratory<br>P.O. Box 1663<br>Los Alamos, New Mexico 87545 |
| Oak Ridge | D. Jared | Oak Ridge National Laboratory<br>P.O. Box X<br>Oak Ridge Tennessee 37830 |
| Pacific Northwest | L. Schmidt | Pacific Northwest Laboratory<br>Battelle Boulevard P.O. Box 999<br>Richland, Washington 99352 |
| Sandia | R.P. Stromberg | Sandia Laboratories<br>P.O. Box 5800<br>Albuquerque, New Mexico, 87185 |

applied must interact with scientists and engineers with detailed knowledge of industry's needs and problems.

The interactions can take a number of forms, including collaborative research, staff exchanges, sabbaticals, participation in conferences, and technology expositions at the labs. They need not be explicitly directed at identifying new uses for lab technologies. Collaborative research, for example, should be undertaken because both parties have an interest in an area of research, not because both desire to identify new uses of lab technologies. But one of the side benefits of the collaborative research is likely to be a better understanding by lab scientists of industry's needs and conditions and by industry scientists of lab technologies and capabilities. In the long run, this understanding should enhance the probability of identifying industrial uses for lab technologies.

At the same time, interactions that are explicitly directed at seeking potential new uses of lab technologies might also be useful. A firm with certain materials needs, for example, or with a need for a test facility, might find valuable technologies at the labs if it deliberately searched for them. Unfortunately, such searches have been rare since the heyday of lab-nuclear industry relations.

Several formal mechanisms for promoting the identification of new uses of lab developed technologies have been established over the past decade. The labs distribute brochures and newsletters describing their technologies and they all have "technology transfer officers," who are required by the Stevenson-Wydler Act of 1980 (see boxed information). But these are useful only as supplements to lab-industry interactions. The transfer officers can serve as liaisons between labs and firms, and the brochures and newsletters can help industrial observers keep track of lab developments. For identifying new uses of lab technologies, however, there is no substitute for face-to-face interactions between lab and industry scientists and engineers.

*Transferring the Technology* — Once a potential application has been identified, the technology must be transferred out of the lab. The obstacles to the transfer vary with the nature of the technology and the technical capabilities of the user. If the technology is in the form of a discrete product (for example, a corrosion resistant material), and if the user is technically capable of adapting the technology, the main obstacles to transfer are associated with DOE licensing practices. DOE, which owns title to work performed by the labs, is usually willing to grant exclusive licenses to lab technologies to small firms and individuals. But it is reluctant to do so for large firms. This attitude becomes a serious obstacle when the costs of adapting and marketing the technology are likely to be high. Few, if any, firms would make the required investment without an exclusive license.

The transfer process is different when the technology to be transferred is in the form of lab expertise rather than a discrete product, or when the user is not capable of adapting the technology. Under these conditions, there are two general methods for transferring the technology. The more common method is for the lab to educate or train the user. This is accomplished through formal classes, workshops, seminars, conferences, staff exchanges, and sabbaticals. When Lawrence Livermore Lab received a grant to transfer its expertise in applications of digital technology, microprocessors, and welding and bonding, it organized and presented a series of courses. Later it assisted the people who attended the courses to apply what they had learned to their jobs. The program led to successful transfer of the expertise to areas such as "a state water project, microcomputerized traffic controllers for a city government, a data collection system at a hydroelectric plant, an improved blood analysis system for hospitals, and improved clean welding techniques for the California Bay Area Rapid Transit System" (6).

Another mechanism for transferring lab expertise is for the labs themselves to apply their expertise to the users' needs by serving as consultants and contract researchers. In some circumstances, this is much more efficient than education as a way of transferring lab expertise. But there can be substantial obstacles to this form of transfer. The most serious is once again DOE's reluctance to grant exclusive licenses to large firms for work performed by the labs. Few firms are likely to pay the labs to work for them if they cannot gain exclusive rights to the results. Another obstacle is DOE's requirement that before a lab can work for a firm, the firm must demonstrate that the work could not be performed in the private sector. DOE imposes this requirement because it is concerned that if the labs were allowed to work for industry, they would be in effect competing with private sector consulting firms. The requirement can be difficult to satisfy. It tends to discourage firms from seeking to have their work performed by the labs and to discourage the labs from seeking firms that might be interested in their work.

DOE's reluctance to grant exclusive licenses and to allow lab work for industry stems from a broad concern for equity. The labs are publicly funded institutions. Therefore, it is inequitable to the public if labs are allowed to serve private needs and inequitable to consulting firms if labs are allowed to compete with them. These concerns are justified — equity is an important value in our society. But there are other important values as well and equity must be balanced against them. Here, equity must be balanced against the benefits of technology transfer. Society is not benefitting at all if for the sake of equity, technological expertise at the labs is left untapped. Furthermore, in the case of lab work for industry, it is not obvious that equity must be sacrificed. If firms for which the labs worked were charged a fee equivalent to that which they would have to pay if the labs were private firms, and if the labs' services were made available to all firms willing to pay this fee, equity would be maintained. The challenge is to devise a fair system for calculating such a fee.

*Lab and Industry Motivation* — The difficulties of identifying spinoff applications and transferring lab technologies to those applications are compounded by a lack of motivation on the part of both industry and labs. For the labs, transferring technologies to spinoff applications is akin to missionary work. By definition it is peripheral, if not irrelevant, to the goals of the labs' programs. Lab managers are primarily concerned with successful performance of their projects, not with possible side benefits. And except for those in programs directed at the market, lab scientists are motivated by science for its own sake, not by unintended industrial applications of their work. If they were interested in industrial applications, they might argue, they would work for industry. The lab reward structure reinforces these tendencies. Publications are the primary measure of performance. At the labs, good science is valued most, not useful industrial applications of good science. Moreover, good science *should* be valued by the labs. The labs' orientation toward science for its own sake is one of their most important assets. Much of their work is long term research, which is best performed in an environment free of pressures to produce practical results. But paradoxically, it is precisely this unapplied orientation that obstructs the transfer of the products, processes, and expertise developed in lab programs to spinoff applications.

An obvious solution to this lack of motivation is to give the labs incentives to transfer their technology to spinoff applications. One way to do so is for DOE and lab management to openly encourage and reward identification of new applications for lab technologies. For example, patent disclosures could be made a measure of performance along with publications. This would induce lab scientists to pay more attention to the possible practical applications of their work without sacrificing the emphasis on good science (since publications would remain an important measure of performance).

Legislation now being considered in Congress might also lead to greater attention to practical applications. Under current law, DOE holds title to patents for work performed at the labs. The "Schmitt Bill" would shift title from DOE to the labs' operators (if the operators so desired) and would also make it easier for lab scientists to gain rights to their inventions. These changes would create the possibility of royalty payments for both operators and scientists, which might induce them to seek possible industrial applications of lab work. But while these changes in patent law might be useful, they are not necessary for making patent disclosures a measure of performance at the labs. In industry labs, scientists cede title to their inventions, yet patent disclosures weigh heavily as measures of performance.

Another way to give labs incentives is for DOE to fund lab programs devised for the express purpose of transferring lab technologies to spinoff applications. The Lawrence Livermore Lab program described earlier is an example. It was explicitly intended to transfer expertise developed in the lab's advanced nuclear research to industry and other government agencies. Such programs have been rare in the past, although legislation already in place could be used to promote them.

The Stevenson-Wydler Act requires that DOE spend 0.5 percent of its budget on technology transfer efforts. Rather than use these funds to create more technology transfer staff positions at the labs, DOE could use them to fund programs like the one at Lawrence Livermore Lab. It could request proposals from the labs for programs designed to transfer lab technology to spinoff applications and then support the most promising proposals.

Another incentive would be to make it easier for the labs to perform work for industry. With the possibility of contracts from industry as inducement, lab scientists and managers might be more likely to seek industrial applications of their expertise. As discussed earlier, however, current DOE policy and licensing practices make it difficult for the labs to work for industry. In order to provide the labs this incentive to transfer technology, DOE would have to modify its regulations governing lab work for industry and become more willing to grant exclusive licenses.

Industry also lacks motivation to transfer lab technologies to spinoff applications. Part of the problem stems from the by now familiar DOE policies and patent practices. Ideally, industry would view the labs as repositories of potentielly useful technologies. It would deliberately search the labs for useful products, materials, processes, and expertise. In reality, however, such efforts would often go for naught. Useful technologies might be uncovered, but in many cases they could not be pulled out of the labs at terms acceptable to industry.

Industry lack of enthusiasm for technology transfer also stems from the generic and age-old problem of organizational resistance to change, especially to change originating elsewhere. Many firms encounter resistance when they attempt to transfer new technologies developed in their own labs to their operating components. If organizations resist such internal technology transfer, they will surely be reluctant to adopt, let alone search for and adapt, technologies developed outside the organization at the national labs.

This resistance to change forces much of the burden for transferring technology to spinoff applications onto the labs. When transferring their technologies to new applications in industry, the labs are in a position similar to suppliers of goods and services in the marketplace. Industry is in a position similar to customers. In order to survive, suppliers of goods and services must be aggressive and entrepreneurial. They must seek customers and convince them to buy their wares. If they took a more passive approach, and waited for customers to come to them, they would soon go out of business. Over the long run, customers learn to value their suppliers' goods and services, and to seek them out when the need arises. But initially, the burden lies with the suppliers. So it must be with the labs. Until working relationships have been established between the labs and industry, the transfer will rarely occur unless the labs "push" their technology to industry. Like suppliers in the marketplace, the labs have to make the initial effort to find customers and to prove the value of their wares to them.

*Spinoff Firms* — Small, high-technology firms that spin off from the labs constitute a mechanism for transferring technology that does not receive as much attention as it should. In the early 1960s, for example, scientists from Oak Ridge formed a company to manufacture silicon surface barrier detectors that they had developed in the lab's nuclear research program. The company eventually grew into "one of the largest worldwide suppliers of nuclear and X-ray radiation detectors and electronics for particle and quantum energy spectrometry" (7).

In the late 1960s, scientists from Los Alamos formed a company to manufacture heat pipes for commercial and individual applications. They had developed their expertise in heat transfer in the lab's Space Nuclear Propulsion Program. Similarly, in the late 1970s, scientists from Argonne formed an engineering consulting firm through which they apply to the power and chemical industries the expertise in thermal hydraulics that they developed while working in the lab's reactor safety program.

Spinoff firms have a high mortality rate. The scientists who create them have little or no experience in business management and marketing and this frequently leads to problems. Furthermore, the firms tend to be limited to labor intensive rather than capital intensive endeavors. They offer technical services, software, and relatively small, discrete products. But even with these limitations, spinoff firms are particularly effective mechanisms for overcoming the usual barriers to transferring lab developed technologies. They overcome the lack of motivation since their sole reason for existence is to transfer the technologies out of the labs. They overcome the education and adaptation problems since the founders of the firms are experts in the technology. They even overcome licensing and patenting problems since DOE is most willing to grant exclusive licenses when it is petitioned by scientists who intend to start a small business venture that commercializes technologies they invented.

Despite the effectiveness of spinoff firms as technology transfer agents, the labs generally provide little support to scientists who might be inclined to create them. To support development of spinoff firms, lab management would have to establish relations with local financial and business communities, identify and encourage entrepreneurs within the labs, and serve as a liaison between the two. This would require significant changes in lab attitudes and practices. In the short run, the labs would gain little from such changes. When a spinoff firm is created, the labs lose top scientists and gain nothing in return except possible competition. But in the long run, supporting the development of spinoff firms could benefit the labs. By nurturing firms with close ties to them, and by establishing relations with business and financial committees, the labs might build a constituency for themselves.

### Transfer to Intended Market Applications

Nuclear reactor technology and alternative energy technologies are the two major examples of technologies that were intended for use in the market at the time they were developed by the labs. They differ from each other in an important respect. By the time the AEC began to promote development of nuclear reactors for civilian purposes, the national labs had become the world's leading centers of reactor expertise. During the 1940s and early 1950s, Argonne and Oak Ridge initiated the development of the pressurized water, boiling water, heavy water, gas cooled, sodium cooled, and liquid metal fast breeder reactors; built and operated a number of experimental reactors; and performed much of the early R&D on the submarine and plutonium production reactors. Therefore, in the early 1950s when the AEC began to promote the development of the nuclear industry, it had no choice but to assign the lead role in reactor development to the labs and then gradually transfer reactor expertise from the labs to industry. In the mid 1970s, in contrast, the labs had had little or no previous experience with the alternative energy technologies assigned to them by the Ford and Carter Administrations. Most of the technologies had originated outside the labs and were as new to the labs as they were to the rest of the U.S. research community.

This difference points to the most fundamental issue in the transfer of technologies developed at the labs for use in the market. If the technology is intended for the market from the outset, and if the labs are not experts in the technology at the time government decides to support its development, does it make sense to allocate the technology's development to the labs? It made sense with reactors because the labs were indeed experts. But if they are not experts, why allocate the technology's development to the labs, have the labs become experts, and then transfer the technology out of the labs to industry? Why not simply allocate the technology's development to industry in the first place and thereby circumvent the problem of transferring the technology out of the labs to industry?

Some private firms that perform government funded R&D have no interest in either manufacturing or using the technology they develop. They perform the R&D solely to generate revenue. When firms such as these are allocated technology development projects, the technology still has to be transferred to the market sector for which it is intended. Consequently, from the perspective of technology transfer, there is little to be gained by allocating projects to these firms rather than to the labs. This suggests a refinement to our question: The issue is not whether a technology's development should be allocated to industry rather than to the labs, but instead, whether it should be allocated to firms that might manufacture or use the technology rather than to the labs.

The best reason for allocating development of a technology to a lab rather than to a firm that might manufacture or use the technology is that the lab possesses special or unusual technical capabilities. For example, one of the projects undertaken by Sandia in the 1970s was the development of instrumentation for geothermal wells. Temperatures in these wells range from 150° to 275°C, so the instruments had to be made of high temperature electronic materials, components, and circuits. Sandia was well suited for the task because it had developed in its nuclear weapons programs "considerable scientific and engineering expertise in electronics instrumentation and system design for hostile environments" (*8*).

Sandia's experience in weapons R&D also proved useful in another non-nuclear energy project — an investigation of true in situ oil shale processing. The lab examined two methods of shale bed preparation, both of which required the use of explosives.

Another example is the labs' work in the nation's fusion effort. The reason often given for placing fusion work in the labs is the long term nature of the enterprise. But actually, the labs' role derives from their special expertise in areas such as inertial confinement, nuclear interactions, radiation effects on materials, and particle accelerator technology.

In each of these cases, the labs applied (or are applying) unusual or special capabilities that they developed in their weapons, nuclear, and high energy physics programs. In effect, they spun off capabilities they had developed in their traditional areas of research to new areas. So the fact that the labs do not have a history of experience with a particular technology does not mean that they lack a useful role to play in its development. To the extent that the labs have unusual or special technical capabilities that can be usefully applied to the development of a new technology, their participation in its development is justified.

Unfortunately, "special technical capabilities" is a nebulous concept. It can refer to capabilities that do not exist in the private sector, or to capabilities that are superior to those that exist in the private sector, or even to capabilities that exist in the private sector but for one reason or another are not available. But however nebulous they may be, identifying the labs' special technical capabilities is critical to the problem of technology transfer. If a lab's special technical capability is defined too broadly, as many industrial observers claim it was during the Carter years, projects that could and should be carried out by the private sector are allocated to the labs, and the problem of technology transfer is unnecessarily created. On the other hand, if special lab capability is defined too narrowly, potentially useful technical contributions by the labs are foregone. The problem of transferring the technology is avoided, but only at the cost of wasted technical and scientific expertise.

*Identifying Special Capabilities* — How then are the labs' special technical capabilities to be identified? There is no simple answer. These capabilities have to be distinguished from capabilities available in the private sector on as technical a level as possible. For each technology development project to be funded by government, lab capabilities must be compared to industry's. This means that the key to identifying special lab capabilities, and thereby to avoiding the unnecessary creation of the need to transfer technology, lies with the decision process by which projects are actually allocated to the labs as opposed to the private sector.

Central to this process is the program manager at DOE. Once it has been decided that DOE will support a program (and this itself is a controversial and complex process), the program manager must assign the project either to the labs or to industry. He chooses between two options: allocate the project to the labs, or request proposals from industry to undertake the project. He does not, and by policy cannot, request proposals from both industry and labs. First he must decide whether to give the project to the labs or to industry, and only then, if he has decided to give it to industry, can he request industry proposals. The program manager must thus determine whether or not the labs have special capabilities with respect to the project without ever examining the capabilities that industry would offer to apply to the project if given the opportunity. Here lies the heart of the problem. The system of assigning projects, as currently devised, does not provide the program manager with detailed, technical information about the capabilities of the labs and industry in the research area in question.

Even if such information were somehow made available, there would still remain the problem of evaluating it. Program managers cannot be expected to possess the technical expertise needed to judge the relative capabilities of the labs and industry. Normally, they turn to the labs for this kind of technical assistance. But seeking help from the labs in these matters would clearly be inappropriate.

Two requirements must thus be satisfied in order to distinguish special lab capabilities from capabilities available in the private sector, and thereby to avoid unnecessary creation of the need to transfer technology:

1. Detailed technical information about the capabilities that the labs and industry would apply to the project must be provided.
2. Expert judgment must be brought to bear on that information.

One way to satisfy these requirements would be to allow labs to respond to DOE requests for proposals along with industry. This was prohibited originally because of a concern that if both industry and labs were allowed to respond to DOE requests for proposals, the labs would win too many projects that could be performed by industry. But ironically, the prohibition has had precisely the effect it was intended to prevent. It places the burden of distinguishing special lab capabilities on program managers while denying them the information they need to make proper judgments. The result has been the assignment of many projects to the labs that industry feels it could have and should have undertaken.

If the prohibition were removed, then when DOE decided to support a project, requests for proposals could be sent to both labs and industry. The responses would provide the necessary information about the capabilities that labs and industry would apply to the project. This would satisfy the first requirement for identifying special lab capabilities. Next, a system for evaluating the relative capabilities described in the proposals received by DOE would have to be devised. The obvious solution is peer review.

Peer review systems are ordinarily expected to compare competing proposals on the basis of their technical merit alone. But in order to judge whether a project should be allocated to the labs or to industry, a second variable has to be taken into account — the likelihood that the technology developed in the project will be transferred. This second variable has to be taken into account for the simple reason that the goal of the entire process is to develop technologies *intended for the market.* A project that leads to technical success, but not to technology transfer, is a failure. This is not to suggest that the likelihood of transfer is more important than or as important as technical merit, but it must be given considerable weight in the evaluation of proposals.

Including likelihood of transfer as a significant consideration would, in effect, bias the allocation process against the labs and firms with no interest in manufacturing or using the technology. If the technical merit of competing proposals were more or less equal, the process would favor firms interested in manufacturing or using the technology, since with them, the problem of transferring the developed technology is circumvented. Labs and firms with no stake in manufacturing or using the technology would be assigned development of technologies intended for the market only when they had special technical capabilities; that is, only when the benefits of their technical capabilities outweighed the costs created by the need to transfer the technology.

This relative disadvantage faced by the labs could be at least partially offset if they somehow increased the likelihood that the technology would indeed be transferred. One way to do this would be to respond to DOE requests for proposals with proposals to perform R&D jointly with firms interested in manufacturing or using the technology. Joint research efforts would allow the labs to apply their technical capabilities, while at the same time forging the kind of industry-lab relations required to transfer technologies out of the labs. The joint proposals probably would have to be structured so that the industrial partners bore at least some of the costs of the project. This would prevent firms from joining the project only because they viewed it as a source of revenue. The willingness of firms to share costs would signal that they believed the technology to be promising and that they believed their lab partners to have capabilities that could be usefully applied to the technology's development.

Unfortunately, joint responses to requests for proposals are prohibited by current regulations. The reason for the prohibition is that unless all interested firms are given an opportunity to submit a proposal jointly with a lab, the firm that actually joins with a lab might unfairly gain an advantage in the competition for the project.

As discussed earlier, such considerations of equity are important, but they ought not to be weighed so heavily that other valuable goals are sacrificed. A joint proposal would give a firm an advantage in competing for a project only if the lab-firm combination produced a superior R&D capability. Should the possibility of a superior R&D capability be foregone for the sake of equity? Even if it should, once again it is not obvious that the equity problem is insurmountable. Requiring the lab's industrial partner to bear a portion of the risk would provide the solution. If the lab-industry team won the competition for the project, the industrial partner would in effect have to pay for the benefits of its advantage. And if more than one firm wished to submit a proposal jointly with a lab, the firms could compete with each other for the right to do so. The firm offering to bear the greatest share of the risk, other things being equal, would be the winner. Or, all the interested firms could participate in the project, each bearing a portion of the risk. This might be a particularly efficient mechanism for ensuring that the technology reached the market (assuming that the firms had an interest in manufacturing or using the technology).

Many other details would have to be worked out before the system for allocating projects among labs and industry could be revised in the ways suggested here (or in any other way that addresses the twin problems of identifying special lab competence and transferring lab developed technology). For example, a procedure for ensuring that small firms would be given an opportunity to work with the labs would have to be devised. But most problems of detail probably could be resolved if the commitment to do so existed. The real question is whether or not such a commitment can be created.

*Transfer of Technologies Allocated to the Labs* — Once a project is allocated to a lab, the problem of transferring the technology must be confronted. A number of hurdles have to be overcome. By far the most serious is that the technology must ultimately be commercially viable. This is only partially determined by the actions of the lab. The process by which technologies are selected for development is at least as important a determinant. No matter how efficient the transfer process, if the technology selected for development and assigned to the labs is inherently unattractive, it will not be successfully transferred. All too often, technology transfer is blamed for failures in commercialization when the real cause is mistakes made in the process by which government selects technologies for development.

Let us assume that the technology selection process functions well. There still remain several obstacles to successful transfer. To begin with, the lab must receive information about the market requirements and constraints that will ultimately govern the use of the technology. Without this information, the lab runs the risk of producing a product that is too expensive or impractical for the intended market. This is one of the reasons why when technical capabilities are more or less equal, projects should be allocated to firms that are in the market sector for which the technology is intended. They are familiar with the market constraints. It follows that when projects are allocated to labs, the best way for them to acquire information about market requirements is to interact with the firms in the marketplace. For example, when Sandia undertook the development of instrumentation for geothermal wells, it established a steering committee comprised of representatives of well logging service companies and oil well producers. In addition, it established a working agreement with a wire logging service company; the company provided design input to Sandia throughout the project.

Not only must information flow from industry to lab, it must also flow from lab to industry. In order to transfer a technology, the labs must educate industry in the particular technology. Once again, lab-industry interaction is required. The most common modes of interaction are subcontracting, collaborative research, and staff exchanges. In Argonne's Lithium/Metal Sulfide Batteries Development Project, for example, Argonne scientists performed the initial research, then invited industrial scientists to the labs to participate in planning and research, and later, subcontracted development to industry. This is not an isolated example. Throughout their non-nuclear programs, the labs have interacted extensively with industry. Indeed, it is difficult to find evidence of any projects intended for the market in which the labs failed to establish some form of interaction with industry.

Unfortunately, lab-industry interaction alone is not sufficient for technology transfer. A serious commitment by industry to integrate the new technology into its existing processes and procedures is also required. This raises a new issue. If industrial commitment to use a technology is necessary for its transfer, then lab technology development projects (or any other market oriented, government funded technology development projects) should not be allowed to proceed for very long without some evidence that industry is interested in using the technology. But at what point in the technology's development should this evidence be required?

On the one hand, the labs need leeway to pursue promising technical ideas without showing evidence of market interest., Fusion is an obvious example. It is still far from the point at which market interest could reasonably be required. On the other hand, since the technology is intended for the market, evidence of interest from industry sooner or later must become an important criterion for evaluating lab projects. The "technology push" provided by the labs must eventually be balanced by "market pull." Certainly by the time the technical feasibility of a technology has been demonstrated, clear indications of industry interest should be required in order for the project to proceed. It could be argued that lack of industry interest is a sign of private sector short-sightedness rather than limited commercial potential. But this possibility does not justify the continuation of projects that have failed to generate private sector support. To achieve success, the technology will have to be transferred, and to be transferred, industry must show a commitment to the technology.

How is such commitment to be assessed? One approach that has often been used in the past but that is nonetheless inadequate, is to base judgments of industrial interest on the willingness of firms to accept cost plus fee subcontracts. Many firms view these contracts as a source of revenue. Their willingness to accept them is by no means a signal that they are interested in using the technology. Another unreliable approach is to rely on market forecasts. Market forecasts are highly sensitive to assumptions about future prices, consumption patterns, technological advances in competing technologies, and so on.

Probably the most reliable indicator of industrial interest is a willingness by the firms that would ultimately manufacture or use the technology to bear some of the costs of its development. The larger the share of the cost that a firm is willing to bear, the more likely it is that the firm will make a serious effort to implement the new technology. From the perspective of technology transfer, then, the most desirable forms of lab-industry interactions are collaborative research projects, in which industry pays its share of the costs; joint research projects, in which industry bears a portion of the total project costs; and subcontracting arrangements, also in which industry bears a portion of the total cost.

These forms of lab-industry interaction can, and sometimes do, occur under existing arrangements. But in general, industry has been reluctant to share costs. The major problem, once again, is DOE's licensing practices. As already discussed, DOE is reluctant to grant exclusive licenses to large firms. In addition, when large firms enter into joint arrangements with the labs, DOE sometimes seeks a claim on the firm's background rights. Clearly, few, if any, firms are willing to share costs if they are denied favorable rights to the work performed in the project or if they are forced to give up their exclusive rights to prior work.

Cost sharing arrangements can only become a major form of lab-industry interaction if DOE modifies its licensing practices. When it enters into negotiations with industry over cost sharing, its paramount goal should be to increase the likelihood that the technology developed at the lab will be transferred. Therefore, it should seek in the negotiations to maximize the share of the cost borne by in-

### Changes Needed

For transfer of technology to spinoff applications,

1. Interactions between industry and lab scientists and engineers should be promoted.
2. The labs should be induced to act, in effect, as suppliers of goods and services.
    - Management should provide incentives to lab scientists to seek spinoff applications.
    - DOE should fund programs designed to transfer lab technologies to spinoff applications.
    - DOE policy should be modified to make it easier for labs to work for industry.
3. Spinoff firms should be nurtured.
4. DOE patent practices should be modified to make it easier for large firms to obtain exclusive licenses.

For transfer of technologies intended for the market,

1. The system for allocating projects among labs and industry should be revised so as to avoid unnecessary creation of the need to transfer technology. Development of technologies intended for the market should be assigned to the labs only when they possess special technical capabilities. As a means for determining when labs possess such capability:
    - Industry and labs should both be permitted to respond to DOE requests for proposals, independently and jointly, and
    - Their responses should be evaluated in a peer review system that weighs both the technical merit of proposals and the likelihood that proposals will lead to successful transfer.
2. In order to increase the likelihood of transfer, lab development projects should be made contingent upon industry interest once technical feasibility has been established.
    - Industry willingness to share costs should serve as the measure of industry interest. Lab-industry interactions therefore should take the form of collaborative research efforts, in which industry pays a share of the costs; joint research projects, in which industry bears a portion of the total project costs; and subcontracting arrangements, also in which industry bears a portion of the total cost.
    - DOE should induce industry to share costs by granting rights to the results of projects proportionate to the amount of cost borne by industry.

dustry. In return, it should be willing to grant industry favorable rights to the project. The precise nature of the rights should depend upon the portion of the project's costs that the firm bears: the larger the portion, the more favorable the rights.

The Schmitt-Ertel bills before Congress as this was being written would simplify this negotiation process and encourage firms to share costs. The bills would grant to industry the patent rights to work performed under government contract. Thus title to the rights would no longer be subject to negotiation. It would belong to industry and this undoubtedly would make industry more willing to share costs. It also would fundamentally alter the nature of the negotiations between DOE and industry because competition between them would be replaced by competition within industry. For attractive projects, more than one firm would usually want the contract (since the contract would guarantee title to rights). The firm that offered to bear the greatest share of the cost, other things being equal, would win. Or instead of competing, the firms could cooperate. DOE could encourage as many firms as possible to participate in the project, each firm bearing a portion of the cost. This, in some circumstances, would be the most desirable outcome. It would spread the benefits of participation in the project, while increasing the likelihood that the technology would reach the market.

## In Conclusion

Technology transfer is a form of interaction among government, labs, and industry. It occurs only if all concerned are willing and able to sustain close and cooperative relations. Under current arrangements, the concerned parties are neither willing nor able. They must fundamentally change the ways in which they interact. A number of such changes have been suggested in this paper (see editorial box). These changes represent considerable departures from past practice. They will not be accomplished easily. But the experience of the past two decades suggests few alternatives.

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Mr. **Volkmer**. Thank you very much, Dr. Pry, for your testimony.

We will now recess. We have a vote on the House floor, and we will recess until 10 minutes after the hour. At that time we will return for questioning. Thank you.

[Brief recess.]

Mr. **Volkmer**. The subcommittee will come to order and we will proceed with the questioning.

I have some questions that I would like to ask the panel. If there are no additional questions today, and if you have no disagreement, the staff may submit some questions in writing which you could reply to at a later date.

At this time I guess I should go to one of the first issues that bothers me the most right now and that was part of the testimony of Dr. Pry right at the end. It concerns what happened out in Chicago, and I guess we don't really have the proper party here to answer it. Maybe Dr. Trivelpiece can give us some idea. Maybe he knows from DOE why this occurred, why the lab exhibits were not permitted to be displayed in Chicago.

Mr. **Trivelpiece**. This event has a long history. I didn't play any active role in the event that transpired in Chicago. The President, when he came into office, suggested that perhaps there were too many Government publications which promoted specific Government activities in a manner that was not entirely consistent with the Administration's position in certain areas. As a result, an OMB order was issued which required that the various departments review what kind of publications they were making and see whether or not they were appropriate. That order contained an instruction that there should be identified in each agency an individual at an appropriate level to carry out this task. In the case of the Department of Energy it is the Assistant Secretary for Congressional and Government Affairs, Mr. Odle. The problem that he found in a sense was that the Department was publishing some things which I think all of us would agree are probably inappropriate and somewhat excessively promotional of the Department's activities. He reviewed those. He has preduced a number of them and I think most of us agree very firmly with his action.

The Department, of course, in its 57 facilities does technical work resulting in publication of a great deal of technical information. Such technical information from my point of view should be simply exempted from the excessive publications review process. It is the natural end product of the scientific work that is done by the people that work in our facilities.

There is also a gray area in between technical publications and promotional publications. In some cases it involves publications and in other cases it involves museums and exhibits and so on. The Chicago conference falls into that gray area.

In this particular circumstance I have to disagree with Mr. Odle. I believe participation in the IR-100 awards meeting is an appropriate thing for the Department to be doing through its contractors.

The question that has come up is the extent to which the Office of Management and Budget intended that the order should be applied to government-owned contractor-operated facilities (GOCO's) as you know, (GOCO's) are contractors and we certainly wouldn't apply such rules to, say, General Electric or TRW. Thus, there is at least some question as to whether or not it was intended that the OMB order should be applied to the GOCO's.

We are looking into that at the moment. Mr. Odle and I have discussed this on a number of occasions. We have not come to an agreement. He understands my disagreement with him in some of these areas, and I understand his position. But he is operating under an order that was delivered from OMB, including authority to carry out activities such as preventing the display of these IR-100 awards.

Mr. VOLKMER. Does the reduction in the publications also diminish technology transfer or at least the opportunity for technology transfer?

Mr. TRIVELPIECE. This is where Mr. Odle and I have had some debate over the issue. It is his position that above a certain cost factor for the laboratories participating in exhibits and demonstrations of this sort; it reflects a higher cost than the Government should be obliged to bear in terms of having that information disseminated publicly.

On the other hand, there are circumstances in which the only way by which you can cause people who are likely to take advantage of this technology; to insure they know about it is through that particular mode. The discussion centers around that particular issue. To put these exhibits up is rather expensive. I think Mr. Odle looks at the costs and then questions whether it is cost effective. The difficulty is how do you determine what constitutes cost effectiveness under the circumstances. He has chosen to make the decision one way. I would have chosen to have drawn the line in a slightly different place in that circumstance.

Mr. VOLKMER. Dr. Pry, do you wish to comment on this at all?

Mr. PRY. Yes, I would like to.

Let me say in advance that Al did not know I was going to bring this up.

Mr. VOLKMER. We already had questions on the reduction of publications. We just didn't know about the incidents in Chicago.

Mr. PRY. A couple of comments. First of all, to my knowledge, the Government laboratories were the only organizations that did not exhibit there and one must ask if it is not cost effective to do so why is it during this time of recession that so many companies were willing to undertake such exhibits which are considered to be expensive.

I think we also have a great concern with cost effectiveness and what we do.

Second, to help, I think in having some understanding with respect to the difficulty of transferring technology, think back in your own mind, if you will, of the number of things that, in your memory, that you know about and you understand and now ask yourself what fraction of those do you really believe in enough to act on.

I think a moment of reflection will tell you a very, very small amount of what you know and understand you really believe in and will act on.

The same thing is true of technology. It is one thing to publish in a magazine. It is another thing to have someone else who reads what you do or listens to what you do and believe in it enough to act on it. That takes a tremendous amount of personal interaction as I am sure you people who deal wilth these issues of getting other people to act day-to-day understand.

In technology it is no different. Fundamentally no one reads in the world. We act by body and mind contact. We must transfer ideas by person-to-person interaction and part of that is, quite frankly, advertising and sales promotion. It is called getting people's attention, sir. I believe very strongly in that issue.

Mr. VOLKMER. Dr. Bennett, do you have any comment, sir?

Mr. BENNETT. I have no further comment.

Mr. VOLKMER. Dr. Pry, is there any reluctance, speaking from the industry side, on the part of the industrial research community to utilize or approach the DOE laboratories for assistance or collaboration on a project that you may be interested in?

Mr. PRY. Sir, I must say it is getting better. I think the vote is still out with respect to some of the things that Dr. Trivelpiece talked about, with respect to things, for example, patent waivers.

I am reminded of an experience back in my earlier days when I was actually doing work with a person from Wright Field—a section head committing to contracts—looking at me in exasperation and saying "why don't you ever invent anything on my money?" I'll get back to that in a minute.

The question of patent waivers or rather the lack of them does, in fact, inhibit U.S. industry from going and working inside the fence at a national laboratory on an industrial problem.

That tends not to be so true for foreign nationals and their firms. I think you find now by actual body count, a predominance of foreign visitors working in the National Laboratories, people from overseas industrial firms.

The reason for that is relatively simple and it goes back to the experience that I told you about earlier. "Why don't you ever invent anything on my money?" Foreign nationals will indeed sign those patent and data agreements but the policing of those agreements is so difficult if the person goes back to Japan or goes back to Germany or goes back to the United Kingdom that the seriousness is not considered to be enough to keep them from working inside the fence.

So I think this new liberalization policy can go a long way toward making the laboratories facilities and expertise as accessible to the United States as it is to other countries.

Mr. VOLKMER. Is, then, the patent matter the biggest inhibition as far as collaboration is concerned?

Mr. PRY. It is a very large one. It is very difficult, really, to get people to get up and move anyway, as you are well aware. Industry sometimes has the attitude, you know, if I could spare a man I would fire him. On the other hand, from the person's point of view, he says if I leave my desk it may get filled; so there are those kind of problems with interchange of people.

Many of those can be alleviated. They are overcome in the largest companies that have large research laboratories where they can spare a few people. But I believe as we proceed here, if we can work out a way that the National Laboratory scientists can also have a sabbatical in industry it would help. It is a two-way street.

It is a question of getting the minds together. Very often the work done in the laboratory is sufficiently good if you can just get it embedded in a different environment in the industry for a short while so that the ideas that would rub off on the people around him, then that would be sufficient to get increased utilization.

In other cases that require very large facilities which the laboratories have, it is necessary for the industry person to come into that facility and understand what is going on. But with that quid pro quo possibility of personal exchange which I would strongly encourage and is part of the ERAB recommendation, I believe that those problems of interchange can be overcome.

Mr. VOLKMER. Dr. Bennett, in your testimony, and I am sure it is in the ERAB report, you raise the question of paperwork and bureaucratic control by DOE over the laboratories. You note that the operations offices position with respect to the laboratories should be modified to focus on management of contracts and to deemphasize their function as policy and programmatic intermediaries between DOE headquarters and the laboratories.

Now, are there existing capabilities, as far as you could determine, at the laboratories to carry out the contracting functions?

Mr. BENNETT. At the laboratories?

Mr. VOLKMER. Yes.

Mr. BENNETT. I believe that there is capability there and certainly if it were decided to deemphasize this particular role of the operations offices the capability is there and could be utilized, yes.

Mr. VOLKMER. Now, Dr. Trivelpiece, has the DOE changed policy from the past? At one time did not the laboratories do a lot of their own contracting?

Mr. TRIVELPIECE. The Government is one party to the contract with the parent organizations that run our laboratories. The operations office constitute a Federal presence which is geographically close to many of the laboratories and is responsible for, among other things, for administration of the contract. The laboratories themselves have always had the authority to contract for the acquisition of materials, services, and so forth, necessary to carry out the Department's specific programs.

Mr. VOLKMER. What is being done in regard to the amount, Dr. Trivelpiece, of paperwork, et cetera, that has been alluded to by Dr. Bennett and ERAB?

Mr. TRIVELPIECE. To some extent this is a little bit in the eye of the beholder; and also it is true. I am sure that the laboratories, like many of us in most circumstances, would like to have an arrangement in which nobody has the right to deliver any paper or report.

On the other hand, there is a collection of reporting requirements which do come about as a result of Government regulations which the Department does not originate of its own initiative. They reflect the Departments merely complying with Federal regulations which result from laws. The end result is a request for information from the laboratories.

Now, it is, I think, undoubtedly the case that the quantity of paperwork has probably grown in the past few years in a manner that is not necessarily consistent with the best utilization of laboratories.

The first question that really needs to be asked is just how much has it increased and why. We have, as I indicated in my opening statement, put together a working group that is to perform this kind of an in-house inventory before we decide precisely what we should do. As a result of that working group, we will try to determine: (1) Where we can streamline our own internal procedures; (2) what is necessary and actually required by Federal statute. Regarding the latter, we should, at least, not send out seven different requests to comply with the same Federal statute with slightly different headings.

In short, there are some streamlined actions that can be taken. The first step is do the inventory. The next step is to find out how that impacts the laboratories and see what we can do on our own. And, following the inventory if it were appropriate and agreeable the Secretary, we should consider inviting an outside auditor to take a look at what we do and see if perhaps they can suggest further streamlining. And, yes, I would concede there is probably a problem there and we should probably do something about it.

Mr. Pry. Mr. Chairman, may I make a comment because I think perhaps a little perspective may be helpful and maybe you already have it, some others may not.

Let us look back to the origin of the GOCO laboratories that were formed back in the AEC days. Clearly then the GOCO laboratories themselves uniquely had the technical expertise. They were put together outside of Government in order to try to overcome some difficulties involved in civil service wage scales for people who were very scarce and also to provide an independent atmosphere equivalent to what industry and universities could provide to what then was real scarce resource.

Industry was also putting people together, as you know, to do research and development in nuclear energy but on too small a scale, and so the GOCO laboratories were formed.

As I point out to my colleagues, somewhere along the way we shot ourselves in the foot. In the early development of the technology there was no doubt about where the expertise was and where the sensible programs were formulated.

As time went by and one began to think about the interactions between the government itself, the agencies and the laboratories, it became clear that a contractor laboratory could not within the logical structure set policy and set programs. So in time program and policy judgments gradually came back up (in what is now DOE but was AEC and ERDA) to be centered primarily in the agency; and the laboratories then simply undertake a service to perform the research.

I think that kind of background is necessary to understand what has happened and why the paperwork seems to have increased tremendously. History doesn't suggest any solutions, necessarily, but I think there has grown to be an inordinate amount of reporting and paper communication between the agency and the laboratories that a few airplane tickets and conversation at the lab level in the labs might help to cure.

Mr. **Volkmer**. Dr. Trivelpiece, does the group or the task force that is working on this problem include people from the laboratories?

Mr. **Trivelpiece**. Not at the moment. It is headquarters staff and operations office staff. It will eventually include laboratory directors. In fact, there is a laboratory directors meeting in Albuquerque on December 15, and we are going to devote about half the day at that meeting to looking into the various management issues in the Department and one of them is that issue so we will certainly solicit their input.

But at the moment it is more or less of an in-house working group homework assignment to just get an idea of what exists as distinct from what to do about it.

Mr. **Volkmer**. What are the present limitations that DOE has on the laboratories for doing outside work for industry or for other Federal agencies?

Mr. **Trivelpiece**. The limitations are to some extent self-imposed. The work for others category at the moment is limited to about 20 percent of a given laboratories budget. Now that is a somewhat arbitrary level. But it is necessary to that first approximation, that business which the laboratory is supposed to do for the Department gets done; and that the work for others not interfere with that primary mission.

For instance, you couldn't have one of the weapons laboratories unilaterally decide that it is going to into the business of manufacturing something that is not consistent with their role in weapons R&D. Within that 20 percent, however, there are things that are consistent with the major laboratories missions. For instance, we do a lot of work for the Department of Defense. We also do the required work for the Nuclear Regulatory Commission in view of their enabling legislation preventing them from having their own separate laboratories. So we are obliged to supply facilities for them.

The total amount of work for others is about $500 million spread out in the laboratories. I would assume implicitly in your question also is the degree to which industry can use them and I think to some extent that is their decision but they are involved in such things as the syncotron light source up at Brookhaven and there the facility was created with the early participation and agreement on the part of potential industrial users and as a result the facilities that are there have capital equipment items that were provided for by industry and they are using the facility. It is approximately a 40-20 split, I believe. It is approximately 40 percent industry and 40 percent university and 20 percent of the facility is utilized by the staff at Brookhaven for their own research.

There are possibilities for work for others and it is a balance, a matter of judgment, to decide what constitutes an approriate level. And whether 20 percent is the right level or not I wouldn't be prepared to defend. That just happens to be where we have made the judgment call at the moment.

Mr. **Volkmer**. Would any of that depend on the demands of the DOE on the laboratory for its own programs that you have ongoing at that facility?

Mr. **Trivelpiece**. Yes, certainly. If it were something that was regarded to be of high priority to the Government and was to be done on an urgent basis at a particular laboratory, then certainly the amount of work for others would be reduced.

As it stands now, for most of the smaller activities, the operations offices have the opportunity to review proposed work for others as well as for new work that might be done is different from the laboratories preexisting activities.

The operations office reviews those and decides whether it is appropriate or not. If there is any dispute, then for many of the laboratories that dispute comes to me to decide and in other cases if it is a large project or a major change from the preexisting laboratory activity then I am obliged to get involved in the decisionmaking activities in any event.

Mr. **Volkmer**. Are any of the laboratory directors able to make independent determinations on the use of the money that they are given by the Government for independent research that they wish to do?

Mr. **Trivelpiece**. Yes. And it varies from place to place and the pattern which is used is different. Oak Ridge Laboratory has the equivalent of an industrial IR&D program in which approximately 2 percent of their allowed overhead charges are for projects which are determined by a committee which then reports to the director. They are audited and it is regarded as an allowed overhead cost. Other laboratories do it on a somewhat more ad hoc basis.

We agree with the recommendations of ERAB. This is an important thing to do and in fact we have already initiated a draft DOE order to try to regularize it so that it is done with some higher degree of uniformity throughout the system than it is now.

We think it is an important thing to do. It is consistent with our understanding of allowed overhead expenditures and we were going to try to push it.

Mr. **Volkmer**. Thank you very much.

I will now recognize the gentleman from Pennsylvania, Mr. Walker, for any questions he may have.

Mr. **Walker**. Thank you, Mr. Chairman.

First of all, let me congratulate you on a very good report. I think it helps this committee define some of the things that we need to know for the future with regard to the laboratory program. Also, I think it will provide some guidance for the entire scientific community over the next several years as to the value of these labs.

Let me explore one thing that I don't find within the report with you and discover if my fears are unfounded and if there is no need to look at the issue and whether or not it is something you decided should not be explored in the context of this report. The problem that I see with the laboratory program is that you are dealing with, to some extent, a governmental mentality within the labs, that people hired stay on for a period of time until they can collect their Government pension and that they tend to be people who brought with them certain concepts originally to these programs which they then carry on throughout the 20 or 25 years that they happen to be in the lab.

It seems to me that that could undermine innovative research. It could mean that in many cases you have almost a kind of institutional incest developed that does not keep the labs at the forefront of scientific developments or even of national science policy as defined by the Congress.

Is there a problem of this kind? If not, how is it being overcome and if so, why isn't it covered in the report?

Mr. **Bennett**. Well, I certainly wouldn't say that in the National Laboratories or an industry or in universities that the retention of personnel past their productive life is not a problem. On the other hand, I would remind you that one of the reasons that these laboratories were set up the way they are is Government owned and contractor operated was to avoid that difficulty which is particularly likely to occur if the staff of the laboratory are in civil service.

As I understand it, the personnel policies in each laboratory are the personnel policies of the contractor. Therefore, this is one of the complaints that we did not hear from the laboratory directors of these laboratories. In contrast I might say the experience I have had in looking at Federal labs that are staffed by civil servants was the problem of lack of turnover and inability to attract young and vigorous investigators into it. The national labs were founded the way they are to avoid that problem and to a very large extent they have done it.

It was not a major complaint that we heard at all and we asked specifically about it and it is not difficult.

Mr. **Walker**. So, in other words, the very fact that they are not governmental as such avoids what I refer to as the governmental mentality developing. Is that what your conclusion would be?

Mr. **Bennett**. I am saying that probably the Government personnel system is most likely to foster this difficulty. They are under different personnel systems and while I wouldn't say the difficulty is not existent, it is not a major problem in operating these labs.

Mr. **Walker**. Do you find in these laboratories that there is a rather ongoing turnover of people? In other words, people who come in, complete their projects and then move on; or do you have people who are staying on for long periods of time?

Mr. **Bennett**. Well, there are people who stayed on for long periods of time but there are also individuals who stay for short periods of time. Many of the laboratories have a process whereby they take individuals on in a post-doctoral thing for 2 or 3 years and at the end of that time reach a decision as to whether they will be offered a more permanent appointment.

But with the exception of Brookhaven and possibly the Berkeley Laboratory there is nothing that resembles academic tenure where once you are in you can't be gotten out and I think even at Brookhaven they had managed that exceedingly well and have succeeded in keeping their very best people there.

Mr. **Walker**. One of the indications in your report is that one of the problems facing laboratories right now is that they are operating, in some cases, at very close to minimal level in terms of funding and that that hinders their performance to some extent and you make three recommendations with regard to that.

One of them talks about each closing some of the laboratories and combining missions. Another recommendation says narrowing the mission of the laboratories so that the funding that is allocated can be better used.

Another one says to make certain that any new kinds of programs that come out go to the laboratories already established rather than establishing new programs, as I understand it.

Did you rank those in preference? I kind of did them backward there. Did you rank those in preference? Which do you think would result in the strongest program if, in fact, we have to move to what you list as some of the more undesirable options?

Mr. **Bennett**. Well, we listed them in reverse order and the idea of actually closing some of the laboratories or merging them we regard as a fairly drastic measure.

Now, the reason for that is that these laboratories are characterized by very expensive large facilities that you simply can't put on a truck and ship to another State. So it would be exceedingly difficult or perhaps even impossible to maintain quality if one decided to actually shut down one of these large laboratories.

We certainly did recommend that if such measures became necessary that it should not involve simply the Multiprogram Laboratories but all of the other technology centers and research facilities that are operated by the Department where such mergers might be possible.

It is interesting if one looks at the cycle of funding and personnel employed in these labs it is a sort of an 8-year cycle where a lot of money is fed into the labs, a lot of personnel, which is precisely what happened the last time in the early 1970's at the time of ERDA.

They have been cut back now to where the levels of personnel and the budget and equivalent dollars are similar to what they were at the leanest periods that the labs felt. And while we were unable to make a programmatic analysis of what further cuts would mean, it is very clear that they are at the margin and if budgetary stringency continues it is going to be necessary to take some of these more drastic measures.

I would say also that a difficulty which I guess is generally felt through the Department in addition to the size of the budget available is the timeliness of the budgetary information.

These laboratories often anticipating a small budget will have to lay off personnel and then they are surprised when Congress adds to the administration request and it is almost a no-win game. It is one of the reasons we made the recommendation which we have reason to believe OMB would be willing to consider that R&D programs be funded on a 2-year cycle.

Mr. **Walker**. The problem with regard to large amounts of funding at the beginning of the program, which eventually tapers off, is mostly a legislative problem. Congress decides early on in some of these programs that that is the sexy political issue at the moment, be it synfuels, the space program, or whatever we decide is a major national priority.

We fund it very heavily at the start and then as it goes off the front pages the funding begins to taper off. In other words, what some of your criticism are directed at is the way the programs are administered out of DOE and I share some of those concerns. I think we also contribute to that here in the authorization process and the appropriation process reacting to those things which are politically attractive at a particular time and then tapering off the funding as the attractiveness and the front page headlines go away.

I guess I am asking if you agree with that?

Mr. **Bennett**. Sure, I am willing to put as much blame on Congress as you will accept. But it seems to me perfectly appropriate that priorities have changed. When you are dealing with R&D programs and personnel it is very hard to take things apart in just a couple of months.

So that if there were a 2-year warning that one could, in an orderly fashion, take the programs down it would be far better, particularly when you are dealing with the kind of highly skilled personnel that are involved here.

It is not fun to lay those off and it doesn't make work in the labs popular and so on. So it is largely a matter of enough time to phase things down rather than having to do it on an ad hoc or sudden fashion.

Mr. **Pry**. May I make a comment to help allay some of your fears?

Mr. **Walker**. Yes.

Mr. **Pry**. First of all, I think if you take a look at the number of Nobel Prize winners that find the laboratories a good environment in which to work, some of your fears with regard to the overburden of bureaucracy and governmental attitude would be allayed.

Second, of course there are people who want to continue to do their thesis for the rest of their life in every organization.

On the other hand, you know there are both good and bad things about a hiring and layoff cycle in a laboratory. Ten years ago the laboratories were down in numbers and now they are down in numbers again. That forces an examination by the laboratory directors of who they want to keep and who they don't want to keep, they then tend to try to get some turnover that is favorable to the improved quality of the laboratory.

The other thing relative to your reference to synfuels, there are bad sides of what you say. There are also some good sides. One knows the way to transfer technology is to transfer bodies. As the Government's priorities shift sometimes because they are successful and sometimes because they are not successful, those people engaged in the changing programs leave the laboratories. They do not disappear from the face of the Earth. Chances are they go to industry and take the knowledge with them. So not all is lost under those circumstances.

Mr. **Walker**. I think that is an interesting point. It is one that I never gave any thought to but that is a very interesting point in that as our priorities drop it means that the talented people are going out and instituting those priorities in other places.

Thank you, Mr. Chairman.

Mr. **Volkmer**. I would like to say that the question of the 2-year cycle for appropriations has been discussed here in the Congress, not just for R&D but for all governmental programs, and I am sure it will probably continue to be discussed. Whether or not we are actually going to see it is another matter.

I don't want to put a damper on what you are saying but I don't think it is going to be. I doubt very much, in my personal opinion, that you will see it just for R&D programs and not for other programs as well, if you understand what I am saying.

Dr. Pry, you alluded to something that I would like to ask Dr. Trivelpiece's opinion on, and its something that the Congress, I think, would have to act on anyway, that is, patents. Let's say that at some lab certain individuals come up with something that is very worthwhile for commercialization and you say that they should be able to go to the private sector and promote it as a small business.

Now, we have a question. Let's say it is developed under a governmental program. In other words, it is at Government expense. We have the patent question there, do we not, Dr. Trivelpiece?

Mr. **Trivelpiece**. I am not sure exactly what the question is.

Mr. **Volkmer**. Let's say Government-sponsored research comes up with something. I don't care where but it has an application in communications, automobiles, medicine or somewhere. The applications that developed were paid for by the Government, but the researchers find that it is very worthwhile commercially for them to be able to go out, let's say, and get an SBA loan and start manufacturing. We have a question of the Government's right to that information.

Mr. **Trivelpiece**. I think that the situation is in fact better and easier to handle than many people now assume. It is assumed that it is very difficult to get patents and to get waivers. In fact, the Department more or less routinely grants to the contractor, say, such as the University of California or the University of Chicago, the rights to the patents for inventions that have been developed by employees at those laboratories.

It is merely necessary for them to ask for them. I think last year the Department granted something in excess of 400 such requests. It is more or less routine. However, there is kind of a lore or mythology that it is impossible. It is in fact not impossible.

The thing that is perhaps missing is the incentive, the motive and the circumstance and that is what the University of California does to reward the employee that comes up with the invention.

Well, it gives them a dollar. The amount of effort that is required to write a patent disclosure, to get it through the legal system of your own institution and then to apply for the waiver and then to have somebody actually purchase it or try to develop it, the leading edge of that activity which involves the individual has very little incentive into it and in fact quite a bit of negative incentive in that he gets $1 dollar and has to do a lot of work and could have done three scientific papers for the same amount of effort that he put in preparing the patent.

Mr. **Volkmer**. But that is a problem between him and the university then?

Mr. **Trivelpiece**. For the most part it is. We are, at this same laboratory directors meeting that I alluded to earlier, we are looking into what might be referred to as the mythical barriers to patents as well as the real legal ones. And I have an impression that to some extent it is lore more than it is in fact impediment in law. They can get the waivers and maybe we can streamline the process or have other patent attorneys streamline the process of granting waivers but those waivers are now possible.

A university can sell or develop those patents and receive commercial return for them through licensing arrangements and could, in fact, return to the laboratory for its use some fraction of that money or could return some fraction of the licensing royalty fees back to the employee who invented it.

They do not in fact do so now but they are not prohibited from doing it by any circumstances of law that I am aware of.

Mr. **Pry**. Mr. Chairman, may I make a comment?

Mr. **Volkmer**. Yes.

Mr. **Pry**. I just can't keep quiet. The reason I brought the point about patents is the following: The major portion of the jobs in the United States are created by companies with less than 20 people. The greatest growth that occurs occurs by those small companies. Where do they come from? They come from entrepreneurial people from much larger companies and occasionally out of some leading universities in the United States. In fact, that was the original wellspring, MIT, Stanford, the story is legend.

Now, there are within our National Laboratories, tens of thousands of such technical people who could, if given the proper encouragement and environment, be a member of that select group of people that start small companies. Now there are several inhibitions.

I am concerned when somebody says that something is possible which, in my mind, is the opposite to saying something is encouraged. I think the problem with respect to the National Laboratories is that entrepreneurship and invention is in fact not encouraged. It is not considered as a neat thing for a scientist to come up with an idea and struggle to see it reach actual fruition, where he is the most capable person to see it through since he is the best champion of his particular cause.

I bring it up simply because it seems to me there is a resource for continuing growth of the country which we somehow or other we are not tapping and giving the proper encouragement.

Mr. **Volkmer**. Thank you very much. I want to thank all three members of the panel for being here today and if the staff has additional questions they will submit them in writing. That will conclude the hearings today. Thank you very much.

[Whereupon, at 12 noon, the subcommittees were adjourned.]

## APPENDIX I

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ADDITIONAL MATERIAL FOR THE RECORD

# The Department of Energy Multiprogram Laboratories

## Prepared by the Multiprogram Laboratory Panel

## September 1982

A Report of the
Energy Research Advisory Board
to the
United States Department of Energy

**Department of Energy**
**Washington, D.C. 20585**

ENERGY RESEARCH ADVISORY BOARD
September 16, 1982

Honorable W. Kenneth Davis
Deputy Secretary of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585

Dear Ken:

I am pleased to forward the final Report of the Multiprogram Laboratory Panel of the Energy Research Advisory Board. This report, approved unanimously by the ERAB on September 10, 1982, was prepared in response to your request on September 29, 1981, to undertake a comprehensive study that will help shape the future of the Department's multiprogram laboratories.

Among the several findings and recommendations of this report is a greater need for stability and continuity in policy and purpose in managing and funding the Laboratories. This need arises from a decade of major shifts, the result of both Congressional actions and shifts in Administration policies. Obviously such changes are fundamental to our system of government and are not likely to be avoided. Some of the major impacts on the multiprogram national laboratories might have been reduced if there had been a single, stable, top-level office concerned only with the laboratories as long-term assets, physical and personnel. The present situation is in part the result of overfragmentation of the long-term programmatic decision process. A major recommendation aims at establishing such a functional office in the Office of the Under Secretary. In addition, the Board recommends that the Department urge the Office of Management and Budget to support rolling two-year Congressional appropriations for research and development with carry-over funding to stabilize further Department and laboratory planning and program execution.

The Board is in full agreement that the multiprogram laboratories are an impressive research and development asset. The Board recommendations, listed in the Executive Summary, are designed to suggest to the Department means by which the laboratories can be utilized even more effectively.

Sincerely,

Louis H. Roddis, Jr.
Chairman
Energy Research Advisory Board

Enclosure

**Department of Energy**
**Washington, D.C. 20585**

ENERGY RESEARCH ADVISORY BOARD

August 31, 1982

Mr. Louis H. Roddis, Chairman
Energy Research Advisory Board
110 Broad Street
Charleston, South Carolina 29401

Dear Lou:

I am pleased to submit the Final Report of the Multiprogram Laboratory Panel to the Energy Research Advisory Board for consideration at its meeting on September 9-10. Since the White House Science Council Federal Laboratory Review Panel has asked ERAB to brief it in mid-September on the results of the laboratory study, action by ERAB at the September 9 meeting would be most timely.

The Final Report completes the Panel's work in connection with the Deputy Secretary of Energy's request to ERAB to provide a comprehensive study to aid the Department in planning for the future of the multiprogram laboratories. There is general agreement among Panel members on the findings and recommendations.

The Panel very much appreciates the cooperation of the laboratories, operations offices, and Headquarters in this effort. To facilitate ERAB's review, I am sending the report to all Board members by copy of this letter.

Sincerely,

Ivan

Ivan Bennett, Chairman
Multiprogram Laboratory Panel

Enclosure

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Professor of Chemistry
University of California
at Berkeley

Dayton Clewell
Senior Vice President (Retired)
Mobil Oil Corporation

Thomas B. Cochran
Senior Staff Scientist
Natural Resources Defense Council

Floyd L. Culler, Jr.
President
Electric Power Research Institute

Martin A. Elliott
Consultant to
Texas Eastern Transmission Corporation

James C. Fletcher
Professor of Technology and
Energy Resources at the
University of Pittsburgh

John S. Foster, Jr.
Vice President for
Science and Technology
TRW, Inc.

Norman Hackerman
President
Rice University

Charles J. Hitch
President Emeritus
University of California at Berkeley

Hans H. Landsberg
Senior Fellow
Resources for the Future

William S. Lee
President and Chief Operating Officer
Duke Power Company

William T. McCormick
President
American Natural Resources Company

David Pimentel
Professor
Department of Entomology and
Section on Ecology and Systematics
Cornell University

Eric H. Reichl
President (Retired)
Conoco Coal Development

Roland W. Schmitt
Senior Vice President
Corporate Research and Development
General Electric Company

John W. Simpson
Consultant to
International Energy Associates, Ltd.

Grant P. Thompson
Senior Associate
The Conservation Foundation

Victoria J. Tschinkel
Secretary
Department of Environmental Regulation

## STAFF

Thomas J. Kuehn, Executive Director
Energy Research Advisory Board
Department of Energy

# PANEL MEMBERSHIP

Ivan Bennett, Chairman*
Dean and Provost
New York University Medical Center

William Carey
Executive Officer
American Association for The Advancement of Science

Floyd Culler*
President
Electric Power Research Institute

James C. Fletcher*
William K. Whiteford
Professor of Technology and Energy Resources
University of Pittsburgh

Charles Hitch*
President Emeritus
University of California

Hans H. Landsberg*
Senior Fellow
Resources for the Future

Henry R. Linden
President
Gas Research Institute

Alan M. Lovelace
Vice President for Science and Engineering
General Dynamics Corporation

Herman Postma
Director
Oak Ridge National Laboratory

Robert Pry
Executive Vice President for R&D
Gould, Inc.

Roland Schmitt*
Senior Vice President
Corporate Research and Development
General Electric Company

John M. Teem
President
Association of Universities for
Research in Astronomy, Inc.

Louis H. Roddis, Jr.*
Chairman
Energy Research Advisory Board
(ex officio member)

Executive Secretary:
Joseph E. Machurek
Office of Energy Research
Department of Energy

Mary Gant
Science & Technology Affairs Staff
Office of Energy Research
Department of Energy

# ABSTRACT

The Final Report of the Multiprogram Laboratory Panel of the Energy Research Advisory Board responds to the Department of Energy's request for "a comprehensive study that will help shape the future of the Department's multiprogram laboratories." The Panel assessed, in energy-related areas, the appropriate roles and missions of the laboratories vis-à-vis industry and universities, the scientific and technological capabilities of the laboratories, the Department's policies and procedures with respect to the laboratories and the effectiveness of the Department's use of the laboratories.

The laboratory complex constitutes an impressive national research and development asset. However, the industry and university research establishments often carry out comparable work, usually with differing goals, objectives, and institutional settings. The issue at hand is how to make use of all of these resources for the benefit of the country as a whole.

The Panel recommends the following major roles and missions for the laboratories:

- Perform the Department's "national trust" fundamental research missions in the physical sciences, including high energy and nuclear physics, and the radiobiological sciences including nuclear medicine;
- Sustain scientific staff core capabilities and specialized research facilities for laboratory research purposes and for use by other Federal agencies and the private sector;
- Perform independent scientific and technical assessment or verfication studies required by the Department; and
- Perform generic research and development where it is judged to be in the public interest or where for economic or technical reasons industry does not choose to support it.

The Panel finds that organizational efficiencies if implemented by the Department could contribute toward optimal performance of the laboratories.The Panel recommends that a high level official, such as a Deputy Under Secretary, be appointed to serve as Chief Laboratory Executive with authority to help determine and defend the research and development budget, to allocate resources, to decide where work is to be done, and to assess periodically laboratory performance. Rolling two-year appropriations by Congress for research and development are recommended as a stabilizing measure. The Panel also recommends that laboratory directors be given substantially more flexibility to deploy resources and to initiate or adapt programs within broad guidelines provided by the Department.

The Panel recommends the following actions to increase the usefulness of the laboratories and to promote technology transfer to the private sector:

- Establish user groups for all major mission programs and facilities to ensure greater relevance for Department and laboratory efforts.
- Allow the laboratories to do more reimbursable work for others (other Federal agencies, state and local governments, and industry) by relaxing constraints on such work.
- Implement vigorously the recently liberalized patent policy.
- Permit and encourage joint ventures with industry.
- Expand laboratory/university cooperation in the training of scientists and engineers at laboratory facilities.

Finally, the Panel finds that some of the multiprogram laboratories are currently funded at close to minimum levels for maintaining their present capabilities. In the event of further budgetary reductions, some measures,such as narrowing laboratory missions or directing additional work to them in lieu of establishing new laboratories, are suggested for preserving as much as possible of the capabilities of the laboratory complex.

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# I. EXECUTIVE SUMMARY

In specific terms, the Deputy Secretary of Energy charged the Energy Research Advisory Board with assessing, in energy-related areas, the appropriate roles and missions of the laboratories vis-à-vis industry and universities, the scientific and technological capabilities of the laboratories, the Department's policies and procedures with respect to the laboratories and the effectiveness of the Department's use of the laboratories. The recommendations of this Executive Summary and the body of the Report respond to these specific charges.

In a broader context, the Deputy Secretary requested "... a comprehensive study that will help shape the future of the Department's multiprogram laboratories."In responding to this request the Multiprogram Laboratory Panel found it appropriate, and indeed mandatory, to consider a broader laboratory role in innovation and productivity in the national economic interest. The Panel concluded in this regard that the present management direction and practices respecting the laboratories, developed over time, are not consistent with their long-range future well-being and, further, that these arrangements deny to the Nation the full benefits of this national research and development asset.

A. The appropriate roles and missions of the laboratories vis-à-vis universities and industry (see pp. 13-15).

1. **Findings**

- The multiprogram national laboratory complex constitutes an impressive national research and development asset. Moreover, it possesses capabilities for the performance of large-scale, long-term, high-risk, multidisciplinary research and development; however, these characteristics in and of themselves do not uniquely define appropriate roles and missions for the national laboratory complex. The industry and university research establishments are capable of and often carry out work comparable to much of that performed by the national laboratories, albeit often with differing goals, objectives, and institutional settings. The issue at hand is how to make the best use of the existing research and development assets of the multiprogram laboratories in the context of the national scientific and technical enterprise.
- Current Administration policy calls for increased reliance upon the private sector for technological advancements but recognizes an appropriate Federal role in supporting long-range, high-risk, potentially high-payoff research and development of national interest beyond that which can be expected from the private sector.The Panel concludes that there exist areas of research and development that require the complementary capabilities of the university, industrial, and laboratory sectors.

2. **Recommendations**

In energy-related areas, the Panel recommends the following functions as appropriate for performance by the national laboratory complex, subject to university and industry participation as noted.

a. **Direct Functions**

- Carry out core elements of the Department's traditional "national trust" fundamental research missions in the physical sciences, including high energy and nuclear physics, and the radiobiological sciences, including nuclear medicine; in so doing,
  - — perform research utilizing their unique capital intensive research facilities to ensure that the capabilities of the facilities and scientific staff evolve appropriately to meet the needs of university, industrial, and other Federal research communities.
  - — exercise stewardship of these facilities and provide associated technical expertise to enable their efficient use by these communities.
- Perform research and development on the health, safety, and environmental externalities incident to promising energy technologies under development (not necessarily limited to those enjoying government funding) whenever high scientific competence or specialized facilities are available at the laboratories or when performance of such work by industry or, where relevant, universities would pose an apparent or actual conflict of interest.

- Perform generic energy research and development where it is judged to be in the public interest or where for economic or technical reasons industry does not choose to support it. Government funding may provide support for either universities, industry, or the national laboratories, consistent with:
  - i) Department utilization of the best available performer for the given task
  - ii) Cooperation with intended users of the technology in determining applications oriented work to be performed in the laboratories
  - iii) Industry access to the facilities and staff of government laboratories for research and development funded privately, or with government funds, under appropriate policy guidance.

**b. Support Functions**

- As requested, and in conformance with explicit policy guidelines and budgets established by the Department, act as agents for the Department in exercising broad technical management responsibities for complex packages of multilaboratory and/or subcontracted research and development work.
- In accordance with applicable Department policy, make the special capabilities and expertise of the laboratories available for technical assistance and reimbursable research and development to other Federal agencies; state and local governments; and regional entities, universities, and industry.
- Within their areas of capability and expertise, contribute toward the education and training of scientists and engineers by providing opportunities for this purpose at the laboratories to university faculty and students, industrial professionals, and, in accordance with national policy, foreign nationals.
- Assist the Department in the discharge of its overall resposibilities by:
  - — providing technical counsel to the Department on national research and development policies and future directions
  - — acting as systems engineers, advisors, and evaluators for the Department in areas where such involvements by others would constitute an apparent or actual conflict of interest
  - — providing a fast start-up or multidisciplinary approach not otherwise readily available to meet quickly an urgent or emergency need for research and development, technical expertise or timely and reliable data of a critical nature
  - — supporting fulfillment of international agreements.

B. The scientific and technological capabilities of the laboratories (see pp. 17-19).

**1. Findings**

- Overall, the Panel finds the scientific and technological capabilities of the laboratories impressive, but DOE organizational inefficiencies and funding policies are obstacles to their full realization.
- The Panel is uniformly impressed with the qualities and resourcefulness of laboratory leadership.
- The scientific and technical resources of the laboratories, including their physical facilities, cannot be utilized effectively under prolonged budgetary uncertainty and the pressure of repetitive crash readjustments in program funding.
- Layering and fractionation of managerial and research and development responsibilities in DOE require the laboratories to interact with DOE on an excessive number of horizontal and vertical levels and with heavy reliance on negotiation. The absence of a coordination and resolution officer with full authority at the Headquarters level giving attention and support to the laboratory directors results in inefficient utilization of laboratory scientific and technical capabilities.

**2. Recommendations**

- Urge the Office of Management and Budget to support rolling two-year appropriations by Congress for research and development with carry over funding to stabilize Department and laboratory planning and program execution.
- Designate a high level official, such as a Deputy Undersecretary, whose sole function is to be the Chief Laboratory Executive with authority to help determine and defend the research and development budget; to allocate resources; to decide where work is to be done; and to assess laboratory scientific, technical, and managerial performance.
- Consistent with the foregoing, modify the roles of the operations offices with respect to the laboratories to focus on management of the contracts with the laboratory operating contractors and to deemphasize their function as policy and programmatic intermediaries between Headquarters and the laboratories.
- Arrange for the laboratory directors to have substantially more flexibility, within overall budgets and broad program guidelines, to reprogram assign-

ed laboratory resources and to initiate or adapt programs in accordance with research and development opportunities. This reprogramming authority should be no less than 5% or more than 10% subject to the satisfactory completion of the original assigned program activity. If additional Congressional authorization for this reprogramming is needed, the Department should seek it.

C. The Department's policies and procedures with respect to the laboratories. (see pp. 21-23).

1. **Findings**

- The laboratories have become grossly overburdened with detailed reporting and other paperwork requirements, the utility of which frequently is not apparent and which unnecessarily divert resources from their research and development missions.
- The Department's laboratory Institutional Planning Process is proving itself valuable, both to DOE Headquarters and the laboratories, although care needs to be taken that it produces a workable plan and not a strait jacket.
- The Department's approach toward appraising laboratory performance has been somewhat lacking in systemization, codification, and management follow-up. The Panel is pleased to note that the Department is in the process of rectifying this situation.
- The Department's restrictions on laboratory work for others, particularly industry, are unnecessarily constraining. Among other things, such restrictions frustrate technology transfer efforts.
- The Department's patent policy, particularly in connection with laboratory work for others, has been among the salient barriers to cooperative relationships with industry and to effective technology transfer. The Panel notes with approval that the Department recently has taken steps to liberalize its policy in this area.

2. **Recommendations**

- Utilize the services of an outside audit contractor familiar with both Government and industry practices to conduct a thorough audit of paperwork requirements in the Headquarters/operations offices/laboratory chain of command.
- Strengthen laboratory Institutional Plans as long-range strategic planning documents, as components of the Department's planning process, and as vehicles for new initiative proposals; de-emphasize their use as constraining budget documents.
- To supplement internal appraisals of laboratory performance, the Department should convene panels from recognized scientific bodies, such as the National Academies of Science and Engineering, to conduct periodic (at intervals not greater than five years) technical audits of laboratory programs in connection with approved institutional plans.
- While maintaining priority status for essential Department missions, allow the laboratories to do more reimbursable work for others (other Federal agencies, state and local governments, and industry) by relaxing constraints on such work.
- Undertake a well-planned education program among Headquarters, operations office, and laboratory staff on the recently liberalized patent policy to ensure that it will be vigorously implemented. In parallel, ensure that the private sector understands the new policy.

D. The effectiveness of the Department's use of the laboratories in meeting its energy objectives (see pp. 25-27).

1. **Findings**

- The Panel finds that the Department has been conservative in envisioning, not to mention implementing, policies by which the laboratories could be more effectively utilized. This conservatism has resulted in a lesser contribution by the laboratories toward meeting the Department's energy objectives than could otherwise be achieved.
- Contrary to past practices, the expertise of laboratory staff and directorate are not being utilized in establishing Department policy and directions for research and development.
- While laudable in principle, the Department's policy of assigning lead missions to the laboratories has been, with few exceptions, generally ineffective because of excessive fractionation of mission assignments, inadequate delegation of authority to the laboratories, and seeming lack of commitment to the policy by DOE management.
- Under present budgetary constraints a number of the specialized research facilities at the laboratories are being operated far below capacity.
- While use of the laboratories for contributing toward training scientists and engineers to meet the Nation's needs has grown in recent years, this use could increase.
- Research and development program planning does not consider adequately end-user views.
- Institutional and doctrinal barriers toward greater laboratory/industry cooperation continue to inhibit achievement of the Department's energy objectives in general and technology transfer efforts in particular.

2. **Recommendations**

- Establish a consultant group composed of all the laboratory directors to utilize more effectively laboratory resources in establishing the Department's research and development policy and directions.
- Implement vigorously the assignment of lead missions to the laboratories, defining these in terms of major applied programmatic missions, and provide for significantly greater laboratory discretion in allocation of resources (within overall Headquarters established budgets for the mission area) and in the selection of performers.
- In setting research priorities, give special weight to making optimal productive use of sophisticated equipment and facilities.
- Establish user groups reporting to the Department, similar to the High Energy Physics Advisory Panel and the Nuclear Science Advisory Committee, for all of the Department's major mission programs and facilities. These could be established independently for each program function or under the umbrella of an overall advisory group.
- Continue to support laboratory/university cooperation in the training of scientists and engineers through on-site participation by faculty and students in laboratory programs, term appointments, fellowships, etc.
- Permit and encourage joint ventures in selected projects with industry, including test and pilot demonstration (located at the laboratories or industrial sites) in order to test economic feasibility and to shorten the time lag for technology transfer.
- In areas of special laboratory expertise and capabilities, allow and encourage the laboratories to work more closely with industry by such means as responding to requests for proposals from industry cooperative groups (e.g., American Society of Heating, Refrigeration and Air-Conditioning Engineers; Electric Power Research Institute; and Gas Research Institute) and to work in partnership with industry in meeting technical needs of Federal agencies, as well as working directly for industry in connection with Federal agency requests for proposals.
- Permit each laboratory to use 1% to 2% of its capital and operating budget for independent research and development at the discretion of the laboratory director in order to enrich their research capabilities.
- Through a deliberate review and study by both the Department and the laboratories, identify institutional and doctrinal barriers to effective technology transfer and implement further actions to ameliorate these.

E. Alternative strategies for making best use of the laboratories in a contrained budgetary environment (see p. 27).

1. **Findings**

- Some of the laboratories are currently being funded at levels close to the minimum consistent with maintaining their present competence and vitality.
- In view of their current broader responsibilities, any further funding reductions that would reduce laboratory staffing below the levels of the mid-1970's would demand that a number of measures, some drastic, be considered to preserve as much as possible the scientific and technical assets of the laboratory complex.

2. **Recommendations**

Certain measures that would help stabilize the laboratory complex in the event of further budgetary reductions have validity in their own right as contributors toward more effective use of the laboratories. These measures, which have been addressed earlier, relate to the lead mission policy and the freeing of the laboratories to do much more work for others. Additional measures recommended for consideration if necessary include:

- Transferring appropriate DOE-sponsored work now performed by other Federal agencies and directing additional work into the laboratories by assigning to them those new tasks for which new laboratories might otherwise be established.
- Narrowing the missions of the laboratories to correspond to the resources available.
- Closing particular laboratories or merging one or more of them with other DOE laboratories or even with other appropriate institutions outside the Department.

## II. INTRODUCTION

This Final Report responds to a request of September 29, 1981, from the Deputy Secretary of Energy (Attachment A) that the Energy Research Advisory Board (the Board) undertake "... a comprehensive study that will help shape the future of the Department's multiprogram laboratories." Specifically, the Deputy Secretary requested the Board's review, appraisal, and recommendations in energy related areas (i.e., other than nuclear weapons related programs) regarding:

- The appropriate roles and missions of the laboratories vis-à-vis industry and universities
- The scientific and technological capabilities of the laboratories
- The Department's policies and procedures with respect to the laboratories
- The effectiveness of the Department's use of the laboratories in meeting its energy objectives.

To perform the requested study, the Board established a Multiprogram Laboratory Panel, composed of both Board and non-Board members (list follows title page). The Panel was charged with reporting its findings to the full Board for review and approval prior to transmittal to the Deputy Secretary.

The Deputy Secretary asked for an interim report giving preliminary recommendations by March 1982 and a final report by September 1982. The Panel's Preliminary Report, issued in March 1982, addressed (a) the appropriate roles and missions of the national laboratory complex vis-à-vis universities and industry and (b) strategies, to be further studied, for making best use of the laboratory complex in a constrained programmatic/budgetary environment. The latter reflected the Panel's consideration of possible means of preserving the laboratory complex as a national asset in light of the Deputy Secretary's expressed concern "... that the scientific and technical strength of the laboratories may be eroded and that their ability to continue to contribute to the Nation's long-range energy needs may be diminished."

In developing its recommendations, the Panel took note of the Administration's proposal of December 17, 1981, to transfer the research and development functions of the Department of Energy (DOE) along with its laboratories to the Department of Commerce, the ongoing overall study of Federal laboratories by the Office of Science and Technology Policy, and the anticipated continuation of budget austerity with regard to Federal support of energy research and development. The Panel additionally consulted in detail with the Department's Headquarters and operations office staffs, the laboratory directors, other Federal agencies, and representatives from industry and universities. Moreover, two or more of the Panel members made full day visits to each of the laboratories, consulting with not only the Director but his principal staff as well.

The Panel found it very important to have a thorough understanding of the origin, development, and history of the laboratories; their changing missions and functions; and the Department's laboratory management processes. Because such background knowledge similarly is important to the reader's understanding of the Panel's findings and recommendations, Section III presents an extensive review of the laboratories in these regards. Readers who are thoroughly conversant with the laboratories need not review this material in detail.

# III. OVERVIEW OF THE MULTIPROGRAM NATIONAL LABORATORY COMPLEX

## A. Historical Perspective

Historically, 12 DOE laboratories were considerd multiprogram. Currently, three of these laboratories, Hanford Engineering Development Laboratory, Idaho Nuclear Engineering Laboratory, and Savannah River Laboratory, are focused almost exclusively in a single program area. This circumstance is not expected to change in the foreseeable future. In its study, therefore, the Panel decided not to include these laboratores (and, for the same reason, the Solar Energy Research Institute). Accordingly, the nine multiprogram laboratories considered by the Panel are:

- Ames Laboratory
- Argonne National Laboratory
- Brookhaven National Laboratory
- Los Alamos National Laboratory
- Lawrence Berkeley Laboratory
- Lawrence Livermore National Laboratory
- Oak Ridge National Laboratory
- Pacific Northwest Laboratory
- Sandia Laboratories

The national laboratory complex had its origins in the Manhattan Project and was formalized and expanded under the Atomic Energy Commission. The multidisciplinary character of the several laboratories sprang initially from the requirements of the atomic bomb project and related demands in radiation biology and health effects for expertise in virtually all the sciences (e.g., physics, chemistry, biology, engineering, and a wide spectrum of specialities within these disciplines). This feature of the laboratories was accentuated in response to the later inclusion of nuclear power research and development as a major laboratory mission. In this period, there evolved the concept of the laboratories as the guardian of "national trust" missions in physical sciences, including high energy and nuclear physics, and radiobiological sciences, including the lead Federal role in nuclear medicine research. Additionally in the past, the laboratories provided strong technical support and counsel in the Department's research and development policy and planning; in recent years the Department has made little use of this capability.

Under the Energy Research and Development Administration (ERDA) and, subsequently, the Department of Energy, the laboratories were uniquely equipped to contribute significantly to the greatly expanded Federal energy research and development thrusts, including their health, safety, and environmental aspects. Over the years the laboratories also undertook other peripheral, but nonetheless essential, functions. These include managing large research facilities and making them available to university and industry researchers, providing their special capabilities to assist other Federal agencies, and functioning as strong international links in scientific and technological areas. Regardless of their historical development, however, the basic questions today concern what scientific and technical needs of the country could be filled by the laboratories and, of these, which ones could best be filled by them.

By policy decision, the national laboratories were established as federally owned and funded facilities operated and staffed by private contractors. Even today they still represent the largest group, in terms of numbers, staffing, and funding, of government owned contractor operated facilities sponsored by the Federal Government or, indeed, by any nation in the world. The national laboratory complex is further characterized by a diversity of operating contractors, which include individual universities, university consortia, and industrial firms (e.g., Ames Laboratory is operated by Iowa State University; Brookhaven National Laboratory, by Associated Universities, Inc.; and Oak Ridge National Laboratory, by Union Carbide Nuclear Division). This diversity of operating contractors is reflected to a noticeable extent in the character of the individual laboratories. All the laboratories encompassed by this study are characterized by a high degree of multidisciplinarity, extensive research facilities, and an organizational and management structure that facilitates ready assembly of project and program teams as required. However, each laboratory differs in significant respects from the others. Some are highly focused on basic research (e.g., Ames Laboratory), others concentrate on applied research and development (e.g., Oak Ridge National Laboratory), and still others are well staffed and equipped in engineering disciplines (e.g., Sandia Laboratories). The totality of multidisciplinary expertise, equipment, facilities, and breadth of capability at the national laboratories substantially exceeds that usually found in most university and industry laboratories. Capsule summaries of the individual laboratories are presented in Attachment B and summarized below.

### B. The Individual Laboratories

The **Ames Laboratory** conducts basic research in materials and chemical sciences, relying upon existing capabilities for preparing high purity metals, alloys, compounds, and single crystals; and conducts materials related research and development in areas such as nondestructive testing of materials. The laboratory, sharing Iowa State University's campus, enjoys extensive cooporation with the University through year-round faculty appointments, graduate student training, and facility-sharing programs.

The **Argonne National Laboratory** (ANL) provides advanced nuclear technology research and development support to the breeder reactor and other fission reactor programs and maintains a substantial, diversified capability in physical and biological sciences in support of reactor efforts. In basic research, a major effort is materials research and development directed toward providing superior new materials for fission and breeder reactors, fusion devices, and advanced fossil energy systems. The laboratory has developed and operates research facilities such as the High Voltage Electron Microscope and the Intense Pulsed Neutron Source. It is now beginning fabrication of a major, user-oriented facility, the Argonne Tandem-Linear Accelerator System (ATLAS), which will be a national facility for heavy ion research in physics.

The **Brookhaven National Laboratory** (BNL) conceives, develops, constructs, and operates large, complex research facilities (e.g., the National Synchrotron Light Source and the Alternating Gradient Synchrotron) that are used to study fundamental properties of matter and are shared with university and industrial scientific communities. The laboratory conducts basic and applied research in technology base areas, both to support research at other facilities and to discover important new directions for research. Major disciplinary strength is found in the areas of high energy, nuclear, and solid-state physics; chemistry; and biology. Biological and medical programs include studies of the health effects of radiation and of chemical substances involved in the production and use of energy.

The **Lawrence Berkeley Laboratory** (LBL) conceives, develops, constructs, and operates large, complex research facilities, e.g., Bevalac and Super Heavy Ion Linear Accelerator (HILAC), that are shared with university and industrial scientific communities. The laboratory capitalizes on its co-location with the University of California at Berkeley to provide a diverse and flexible assembly of scientific talent for research and advanced development with major research programs in high energy physics, nuclear physics, basic energy sciences, conservation and solar energy, coal research, inertial confinement fusion, geochemistry, computer science, and mathematics.

The primary role of **Lawrence Livermore National Laboratory** (LLNL) is the research, development, and testing of nuclear weapons designs. Expertise developed in this area is also applied to related areas of defense research such as inertial confinement fusion, nonnuclear ordnance, and particle beam technology. LLNL also undertakes research and development technologies of national interest, primarily in the field of energy, where the skill or facilities requirements are unique and synergistic to the weapons effort. As a result, the Laboratory has ongoing programs in magnetic fusion energy, laser isotope separation, biomedical and environmental studies, in-situ coal gasification and oil shale retorting, energy storage systems, transportation energy conservation, and solar energy research and development.

The **Los Alamos National Laboratory's** (LANL) primary mission is the application of science and technology to problems of national security, that is, to the maintenance of a strong defense, the fulfillment of arms control commitments, and the guarantee of a secure energy supply for the future. Major programs include developing nuclear warheads, designing and testing advanced technology devices, and maintaining an innovative weapons design program. In nuclear fission, programs include testing advanced reactor fuel elements, modeling reactor accident results for the Nuclear Regulatory Commission, evaluating biomedical consequences of nuclear energy production, and developing effective nuclear waste disposal methods.

The **Oak Ridge National Laboratory** (ORNL) primarily supports the fission nuclear fuel cycle and magnetic fusion energy development (advanced toroidal devices such as Tokomak and Elmo Bumpy Torus) through scientific research and technology; identifies and solves generic research problems in energy technologies such as materials, separation techniques, chemical processes, and biotechnology; and is the major national source of production of stable and radioactive isotopes. Energy technology development at ORNL also includes other important efforts in residential and commercial energy conservation, renewable energy sources, ecology, biology, and coal conversion and utilization.

The mission of the **Pacific Northwest Laboratory** (PNL) is the advancement and use of scientific and engineering technology for national security and the nation's multiple energy needs. In accomplishing this mission, high priority is given to safe and reliable nuclear energy and to promising new concepts and technologies for operations at Hanford. Areas of disciplinary strengths and concentration include nuclear waste process development, nuclear fuel development and evaluation, spent-fuel storage and reprocessing, inhalation toxicology, bioelectromagnetics, biology, ecology, atmospheric sciences, corrosion chemistry, biomass research, nondestructive testing and evaluation, materials characterization and research, chemical engineering, health physics technology, and energy economics and policy analyses.

**Sandia Laboratories'** principal mission is research, development, and engineering of nuclear weapon systems, except for the nuclear explosive. Sandia is also responsible for major energy programs in fossil, solar, fission, and basic energy sciences. Its strength lies in its ability to conduct large, interdisciplinary engineering projects that are both technologically risky and sophisticated. Fundamental understanding and technological development are melded to create an environment conducive to generating new products and processes.

### C. Current Status of the Laboratories

Funding and staffing at the multiprogram laboratories increased significantly under ERDA. The high level of staffing reached in the late 1970s later became a matter of concern within the Department of Energy; measures to control laboratory growth, largely successful, were instituted, and employment leveled off at about 41,000. The policies of the present administration, expressed through budgetary retrenchment in areas deemed within the responsibility and capability of industry, caught the laboratories overextended in areas no longer considered appropriate for Federal support. As a consequence, nondefense-related staffing of the laboratory complex at the end of the FY 1982 is lower by about 10% (3500 people) than in FY 1980. Significant staff reductions are possible during FY 1983, depending on the final budget. Staffing problems have not been uniformly distributed among the laboratories. The weapons laboratories were least impacted, although reductions are taking place in some energy research areas, notably in solar energy. The nonweapons laboratories are expected to be at 10% to 20% below peak employment by FY 1983.

### D. Special Laboratory Roles

The laboratories commonly are perceived primarily as performers of research and development. However, they currently play additional significant roles that need to be evaluated in considering the future roles and missions of the laboratories. These current additional roles include the following.

**Systems Engineers/Technical Consultants.** Laboratories play the role of system engineers, advisors, and evaluators for DOE. This is particularly true in those areas where industry has an economic or proprietary interest and, if called upon, might be perceived to have a conflict of interest (e.g., coal conversion processes needing government funding, nuclear safety, etc.). The laboratories help the Department to be an informed buyer in making its commitments outside the laboratories. In this role, too, the laboratories address public health, safety, and environmental issues. Laboratories perform checks and gather data on existing systems and make technical assessments of safety and health-related work. For example, the laboratories have been called upon to prepare drafts of environmental impact assessments and statements. Again, these are areas where industry might be perceived to be less objective about results, were they to produce them. Because choosing areas where data are needed requires a detailed knowledge of rather large, complex engineering entities, the universities have normally been involved only in the basic research end of the spectrum.

**Quick Response Service.** Laboratories are frequently called upon to provide a fast start-up or apply their multidisciplinary expertise to meet quickly an urgent research and development or technical need. The most recent needs of this kind have been the Three Mile Island accident and the Strategic Petroleum Reserve fire. Many lesser ones involving technical problems occur on a far more frequent basis, and the laboratories are called upon to drop what they are doing and apply their resources to those problems to obtain a rapid and correct answer.The laboratories also have been requested to provide services that, while they have had some technical component to them, did not require innovative technologies or discoveries but rather quick application of knowledgeable manpower. For example, Oak Ridge National Laboratory has provided several technical assessments and analyses in support of residential conservation service legislation.

**Stewardship.** Laboratories are stewards of many special research facilities that are nationally and internationally unique or at least very rare. The laboratories maintain the continuity of long-term research and make the facilities available to a variety of institutions, usually universities but more recently to industry, even for proprietary research.These research facilities and resources include nuclear reactors, accelerators, atomic particle-scattering facilities, light sources,special equipment, national environmental research parks, and large animal populations.

**Agents.** For some years laboratories have acted as technical agents for DOE as it adopted a policy of decentralization. Laboratories were given lead missions involving broad technical management responsibilities for implementation planning, organizing, monitoring, and carrying out complex packages of research and development work for the Department, using explicit policy guidelines and budgets established by DOE Headquarters. Much of this included subcontracting a majority of the work to industry and universities.

**Production.** Some laboratories have unique capabilities to produce items of commerical value, such as radioactive and stable isotopes produced at Oak Ridge National Laboratory with annual sales of $15 million. Industry has not found it profitable to invest its own money for such purposes, but this is an area vital to health and industrial processes and for which there is an international market and competition.

**Local and Regional Service.** Laboratories, by reason of their geographical locations, have been consultants to state and local governments and have undertaken technical research specific to their geographical regions. Depending upon special circumstances, they provide coal support to other Federal activities in the vicinity and to the other local DOE operations offices in their roles as project managers when they need special technical work performed quickly to provide a basis for making decisions. Examples include assistance to several states by Ames Laboratory in the use of atomic emission and mass spectroscopy techniques for trace metal analysis of air and water; assistance to the city of Berkeley, California, by Lawrence Berkeley Laboratory in the form of technical advice and demonstrations with regard to building energy conservation; and assistance to New York State by Brookhaven National Laboratory in using concrete polymer developed at that laboratory on highway bridge repairs. Additionally, universities have aggregated some of their work around their neighboring DOE laboratories. For example, both Los Alamos National Laboratory and Sandia Laboratories have relationships with the University of New Mexico; Argonne National Laboratory and its associated universities have developed close interaction and mutual support.

**Training and Education.** Laboratories have frequently been involved in nationwide training and education programs. These include allowing doctoral work to be done at the laboratories, hiring and training postdoctoral students for short periods of time, and actually establishing education branches for use of special facilities at the laboratories as, for example, at Lawrence Livermore and Los Alamos National Laboratories.

**Work for Other Federal Agencies.** All the laboratories perform some work (10%-20%) for agencies other than DOE, usually because they have special facilities and capabilities or because the law intends it so [e.g., most laboratories perform work funded by the Nuclear Regulatory Commission (NRC), because the law requires DOE to make its laboratories available to NRC]. One example of work for another agency is the development by Sandia Laboratories for the National Oceanic and Atmospheric Administration of acoustic transmission systems for communicating data from ocean bottom instrumentation to surface receivers. Another example is the work for the National Institutes of Health by Lawrence Berkeley Laboratory involving biophysical studies on the effects of heavy ions and clinical trials of the effectiveness of heavy ions as a cancer treatment modality, both employing the Bevalac.

## E. External Relationships

The laboratories have a long history of relationships with the university and industry communities through a variety of mechanisms. For some laboratories cooperation with universities has been particularly close because the operating contractor is a university or university consortium. In most laboratories, means are provided for large numbers of university faculty and students (up to 20% of full-time equivalent staff) to work at the laboratories for extended periods. University researchers commonly use unique facilities and equipment at the laboratories. Some laboratory research and development is subcontracted to universities. In FY 1981 this amounted to about $39 million in direct subcontracts plus the not readily calculable value of the universities' free access to unique laboratory research facilities. Laboratory relationships with industry, in general, have been less intimate, but nonetheless significant. Occasionally industry personnel work at the laboratories side by side with laboratory staff on problems of mutual interest. For example, as many as 11 industry personnel at a time from six private firms participated in this manner in Argonne National Laboratory's battery development program. Laboratory research and development subcontracting to industry is common. The best figures the Panel has been able to obtain suggest that the latter approximated $260 million in FY 1981. This work largely consisted of technical and engineering analyses and component and hardware development. In addition, procurements from industry approximated $640 million. In an effort to create closer ties and cooperation, the laboratories and the Industrial Research Institute have established a joint task force to explore and develop means of greater interaction. Close ties are also maintained with the international community through a variety of means, including staff exchanges and the training of foreign nationals at laboratory facilities. Both university and industry scientists serve on outside review committees established by the laboratories to advise them on the quality and performance of their work although use of this process is somewhat spotty. In addition, to comply with the Stevenson-Wydler Technology Innovation Act of 1980, the laboratories have upgraded their technology transfer programs. Most of these external relationships are two-party, in the sense that they are focused on either industry or academia. The most important mechanisms are the following.

**User Facilities.** A prime purpose of national laboratories is to maintain and make available unique facilities needed by scientists and engineers in many institutions for their research and development work. The emphasis has been on use of facilities by individuals, mainly from universities, but industry use of these facilities is increasing. For example, Brookhaven's National Synchrotron Light Source has been used by 12 major companies, and Sandia's Combustion Research Facility, by seven companies.

**Communications Services.** Laboratories serve as catalysts and facilitators for scientific communication by (a) arranging a variety of ways for visitors and guests to spend time at a laboratory, often directly involved in laboratory programs, and encouraging laboratory personnel to visit industry and universities; (b) taking the initiative in setting up conferences and workshops on topics of national interest; and (c) helping to build and support communication networks that meet national needs, such as between academic disciplines, between industry and academia, and between policymakers and the research community.

**Contracting.** Laboratories contract with industry and universities for research and development, provide research and development support for the performers, and serve as a source of technical direction and quality assurance for government programs, a role that for several laboratories has grown considerably since the creation of DOE. On occasion, they contract from industry and utilities for research and development as well as perform work for other nonfederal sponsors (such as state and local governments). For example, Oak Ridge National Laboratory received contracts from 74 nonfederal sponsors in FY 1981 and FY 1982.

**Other Partnership Arrangements.** Other joint arrangements include (a) direct collaboration whereby researchers work together, most often on an informal personal basis since more formal arrangements can be cumbersome; and (b) complementary assistance whereby the partners help to meet each other's needs in such ways as providing technical assistance quickly, serving on advisory committees, reviewing draft reports and proposals, and working together on committees and panels and in scientific and professional societies.

**Built-in Institutional Links.** Each of the multiprogram DOE laboratories is, in fact, operated by a nongovernmental institution, a university or university assocation, or a profit or nonprofit firm. Many of these laboratories are also linked to associations of regional universities, and some have developed special links with institutions in their own neighborhood (e.g., Los Alamos and Sandia with the University of New Mexico and Oak Ridge with the Tennessee Valley Authority and the University of Tennessee).

**Production Activities.** In certain special cases, on behalf of DOE, laboratories are not just developers but also producers of devices and materials (e.g., the radioisotopes produced at Oak Ridge and Los Alamos). These external relationships of laboratories are discussed in considerably more detail in Volume II, Chapter 5.

**Use of the Laboratories for Education and Training.** National laboratories host a steady stream of scholars, teachers, and students. In many cases, these visits involve temporary appointments at the laboratory. Typically, for example, Oak Ridge, Argonne, and Brookhaven National Laboratories will each have about 1,000 university faculty members and students in residence for all or part of a year, participating in laboratory research programs and exchanging professional insights with laboratory staff. For instance, the Division of Educational Programs at Argonne operates eight programs for visiting faculty, eleven for graduate students, six for undergraduate students, and two for high school students. Guests from universities at Brookhaven during 1981 (including research collaborators) were affiliated with 123 U.S. colleges and universities and 46 foreign universities. Similarly, Lawrence Berkeley Laboratory customarily has on site 500 graduate students doing thesis research. These opportunities for participation and interchange bring many of the best minds in the nation to the national laboratories, and they contribute to building and maintaining a pool of trained manpower for energy research and development.

The roles of DOE laboratories in training industrial research and development personnel are limited. Because education and training are fundamental roles of universities in this country and because industrial firms often provide their own training programs for employees, specific training activities by a laboratory have generally been considered unnecessary and inappropriate. Under a particular set of circumstances, however, laboratories have taken on such responsibilities in the past, and they continue to offer a few short courses and other short-term training programs in specialized areas. These educational and training programs are discussed in more detail in Volume II, Chapters 5 and 6.

# IV. THE APPROPRIATE ROLES AND MISSIONS OF THE LABORATORIES VIS-À-VIS UNIVERSITIES AND INDUSTRY

## A. Assessment of Roles and Missions

The roles and missions of the laboratories, industry, and universities necessarily must be assessed in the context of the overall Federal energy research and development role as articulated by the Administration. In the Panel's understanding, the Federal policy emphasizes increased reliance on private initiatives for energy technology development and implementation. The Federal policy, however, recognizes an appropriate Federal role in long-range, high-risk, potentially high-payoff energy research and development where profit prospects are remote or where society at large rather than individual private investors would benefit from such research and development.

The comparative major capabilities and limitations of multiprogram laboratories, universities, and industry in the context of the Federal energy research and development role can be described with proximate confidence. The laboratories are well suited for basic and long-range, high-risk research and development, large multidisciplinary efforts, and operation of large capital-intensive research facilities, but they come up short in marketing/commercialization skills. Universities stand out for excellence in basic research and narrowly focused applied research and development, but they are not notably oriented toward market involvement or, with the exception of some sponsored research institutes, for large-scale multidisciplinary efforts. Industry stands out in development, demonstration, and commercialization activities and often displays impressive capabilities for large multidisciplinary efforts, but it tends to focus its basic research and high-risk research and development on corporate goals, unless funded by the Government.

Given these in part complementary and in part overlapping capabilities, the question at issue is how to make best use of the multiprogram national laboratories in the context of the overall energy-related national scientific and technological enterprise.

Each of the laboratories currently is identified with one or a few substantive areas of concentration. These core areas can be expected to remain central to any national energy policy for years to come and are widely recognized as areas of laboratory excellence. In each of these, the laboratories have established strong relations with the users of the research and development. In general, these core areas can be generically identified as follows:

| | |
|---|---|
| Ames | — Fundamental Energy Science |
| Argonne | — Nuclear Energy,<br>Fundamental Energy Science |
| Brookhaven | — Fundamental Energy Science |
| Lawrence Berkeley | — Fundamental Energy Science |
| Los Alamos | — Defense |
| Lawrence Livermore | — Defense |
| Oak Ridge | — Fundamental Energy Science, Magnetic Fusion, Nuclear Energy (fuel cycle, primarily) |
| Pacific Northwest | — Waste Management |
| Sandia | — Defense |

As a first approximation, therefore, the role of the laboratories should encompass generically these core areas.

By virtue of the work they perform in their core areas, the laboratories develop expertise applicable to other areas (e.g., the drilling technology developed in the weapons laboratories can be applied in in-situ gasification). The question is, when should work in such other areas be assigned to the laboratories rather than to industry, universities, or nonprofit organizations? One way to resolve this question is to allow the laboratories to compete in these other areas with the other sectors in response to government requests for proposals, basing the competition on expertise and the likelihood that the results will be successfully transferred to the intended users. Short of this, the laboratories generally should be assigned research and development intended ultimately for market application when they have special expertise in the area. More specifically, research and development at the laboratories should be primarily in specific areas of science and technology that respond to:

- The Department's "national trust" missions
- Needs for which the laboratories' scientific or engineering capabilities for making salient contributions are demonstrably superior to those of universities and industry

- Long lead-time innovations requiring new scientific knowledge for which adequate private sector commitments and resources are unavailable
- Path-breaking basic research in support of government missions to which particular laboratory resources are matched
- Environmental and health research where performance by others would be seen as constituting a conflict of interest.

The proper role of DOE in energy research and development is to fund and manage those activities for which industry lacks incentives (e.g., environmental, health, and safety research and development) or for which the economic benefits, although substantial, are either sufficiently uncertain or so far in the future that industry chooses not to risk its own resources. In addition to the question of appropriate topics for Federal funding, there is the question of performance. Who is to perform the energy research and development that DOE sponsors? As a general guideline, DOE should choose the performer that can do the best job. Ability to do the job should be measured according to two variables, technical capability and ability to transfer the results to intended users. Further guidance on the choice of performer for a particular research and development task is given by considering the following three situations: (a) industry or universities have capabilities equal to those of the national laboratories, (b) one segment has the necessary capabilities whereas the others do not, and (c) the necessary capabilities do not exist.

**Equal Capabilities.** Situations involving equal capabilities need to be judged on a case-by-case basis. If the technology is intended for the market and private firms that have an interest in manufacturing or using the technology have the necessary skills and facilities, they should probably be assigned the work. If, however, the firms with the capability to perform the project are interested in it solely for the purpose of doing business with the Government, no special advantage accrues from assigning the work to them rather than to national laboratories.

**Unequal Capabilities.** In choices between potential contractors with unequal capabilities, generally, the work should go to the organization having the best capabilities. Building duplicate facilities or skills is, in most instances, a waste of the taxpayers's money. Exceptions are cases involving real or perceived conflicts of interest.

**Capabilities Do Not Exist.** Where capabilities do not exist, a case-by-case judgement is required. If government funding to create a private sector capability would result in leveraging of significant private funding or tightening the connection to production capability, then industry should be the choice. Otherwise, the work should go to either universities or national laboratories, depending on the nature of the research. The creation of new national laboratories within the private sector is inconsistent with Administration policy concerning roles of Government versus those of the private sector. Similar considerations apply to universities. The Government should be alert to opportunities for building facilities and equipment to assist universities in their teaching and research mission.

### B. Findings and Recommendations

#### 1. Findings

- The multiprogram national laboratory complex constitutes an impressive national research and development asset. Moreover, it possesses capabilities for the performance of large-scale, long-term, high-risk multidisciplinary research and development; however, these characteristics in and of themselves do not uniquely define appropriate roles and missions for the national laboratory complex. The industry and university research establishments are capable of and often carry out work comparable to much of that performed by the national laboratories, albeit often with differing goals, objectives, and institutional settings. The issue at hand is how to make the best use of the existing research and development assets of the multiprogram laboratories in the context of the national scientific and technical enterprise.
- Current Administration policy calls for increased reliance upon the private sector for technological advancements but recognizes an appropriate Federal role in supporting long-range, high-risk, potentially high-payoff research and development of national interest beyond that which can be expected from the private sector. The Panel concludes that there exist areas of research and development that require the complementary capabilities of the university, industrial, and laboratory sectors.

#### 2. Recommendations

In energy related areas, the Panel recommends the following functions as appropriate for performance by the national laboratory complex, subject to university and industry participation as noted.

**Direct Functions**

- Carry out core elements of the Department's traditional "national trust" fundamental research missions in the physical sciences, including high energy and nuclear physics, and the radiobiological sciences, including nuclear medicine; in so doing,
  - — perform research utilizing their unique capital intensive research facilities to ensure that the

capabilities of the facilities and scientific staff evolve appropriately to meet the needs of university, industrial, and other Federal research communities.

— exercise stewardship of these facilities and provide associated technical expertise to enable their efficient use by these communities.

- Perform research and development on the health, safety, and environmental externalities incident to promising energy technologies under development (not necessarily limited to those enjoying government funding) whenever high scientific competence or specialized facilities are available at the laboratories or when performance of such work by industry or, where relevant, universities would pose an apparent or actual conflict of interest.
- Perform generic energy research and development where it is judged to be in the public interest or where for economic or technical reasons industry does not choose to support it.

Government funding may provide support for either universities, industry, or the national laboratories, consistent with:

i) Department utilization of the best available performerfor the given task

ii) Cooperation with intended users of the technology in determining applications oriented work to be performed in the laboratories

iii) Industry access to the facilities and staff of government laboratories for research and development funded privately, or with government funds, under appropriate policy guidance.

**Support Functions**

- As requested and in conformance with explicit policy guidelines and budgets established by the Department, act as agents for the Department in exercising broad technical management responsibilities for complex packages of multilaboratory and/or sub-contracted research and development work.
- In accordance with applicable Department policy, make the special capabilities and expertise of the laboratories available for technical assistance and reimbursable research and development to other Federal agencies; state and local governments; and regional entities, universities, and industry.
- Within their areas of capability and expertise, contribute toward the education and training of scientists and engineers by providing opportunities for this purpose at the laboratories to university faculty and students, industrial professionals, and, in accordance with national policy, foreign nationals.
- Assist the Department in the discharge of its overall responsibilities by:
    - providing technical counsel to the Department on national research and development policies and future directions
    - acting as systems engineers, advisors, and evaluators for the Department in areas where such involvements by others would constitute an apparent or actual conflict of interest
    - Providing a fast start-up or multidisciplinary approach not otherwise readily available to meet quickly an urgent or emergency need for research and development, technical expertise or timely and reliable data of a critical nature
    - supporting fulfillment of international agreements.

## V. THE SCIENTIFIC AND TECHNOLOGICAL CAPABILITIES OF THE LABORATORIES

### A. Laboratory Resources

The multiprogram laboratories represent an accumulation of human and physical capabilities that have been built up over several decades. As a system, they are the largest concentration of such resources in the country and probably the world.

Within a total employment of about 40,000, the multiprogram laboratories employ 8500 full-time equivalent scientists and 5900 full-time equivalent engineers (Table 1). These are supported by an annual budget of close to $3 billion or about 9% of Federal expenditures for research and development. Each of the laboratories contains a broad variety of disciplines spanning the physical sciences and biosciences and engineering and includes a few social sciences.

Table 1 shows that the three weapons laboratories are also the three largest in employment, making up over half of the laboratories' total.

The current book value of the plant and equipment of the nine multiprogram laboratories is about $2.5 billion. The replacement cost of the facilities would be several times that. In addition to being well equipped, the multiprogram laboratories possess a number of unique facilities that attract many users from the private sector. The major facilities are listed in Attachment B. Examples of widely used facilities follow:

| | |
|---|---|
| Argonne National Laboratory | Intense Pulsed-Neutron Source |
| Brookhaven National Laboratory | Medical Research Center<br>National Synchrotron Light Source |
| Lawrence Berkeley Laboratory | National Center for Electron Microscopy<br>88-inch Cyclotron |
| Los Alamos National Laboratory | Meson Physics Facility |
| Oak Ridge National Laboratory | National Center for Small-Angle Scattering Research |
| Sandia Laboratories | Combustion Research Facility<br>Central (Solar) Receiver Test Facility |

**Table 1. Number of scientists and engineers employed at the multiprogram laboratories[1] (full-time equivalents)**

| | Scientists | Engineers |
|---|---|---|
| Ames Laboratory | 343 | 46 |
| Argonne National Laboratory | 1,035 | 605 |
| Brookhaven National Laboratory | 712 | 342 |
| Lawrence Berkeley Laboratory | 734 | 304 |
| Lawrence Livermore National Laboratory[2] | 1,600 | 1,105 |
| Los Alamos National Laboratory[2] | 1,725 | 905 |
| Oak Ridge National Laboratory | 950 | 660 |
| Pacific Northwest Laboratory | 525 | 340 |
| Sandia Laboratories[2] | 904 | 1,592 |
| | 8,528 | 5,899 |

[1] Based on data from the most recent institutional plans or from private communications from the laboratories.
[2] Approximately 50% of these scientists and engineers work in defense programs.

The laboratories are organized to respond quickly to the demands of the sponsoring agency to apply management and multidisciplinary talent to a technical problem. In recent years, there have been increasing tendencies to create multilaboratory programs or task forces to bring the best available talent to bear on a problem. A variety of management skills have been used to propose, design, construct, and operate the major facilities that form part of this complex. The laboratories generally turn to subcontractors in the private sector for detailed design and construction services; Sandia, for example, managed about $320 million of procurement in FY 1981.

The management resources of the laboratories are also utilized in their lead mission roles, tools for decentralizing program execution. The number of lead missions currently assigned to the multiprogram laboratories is 32. These include some major programs such as large component development at Argonne, liquid metal fast breeder reactor physics and safety at Argonne, consolidated (nuclear) fuel reprocessing at Oak Ridge, and photovoltaic engineering development at Sandia. Many minor programs, such as reduced-enrichment fuel for research reactors at Argonne, building ventilation at Lawrence Berkeley, and annual cycle energy system at Oak Ridge, are also included.

### B. Assessment of Capabilities

The Deputy Secretary's charge in regard to the scientific and technological capabilities, taken to an extreme, would involve an extensive and in-depth analysis covering such questions as:

- Laboratory capabilities for program execution and project management
- The areas of greatest strength (and weakness) in laboratory functional capabilities (e.g., research vis-à-vis engineering development; among disciplines; or for small tasks versus complex, multiyear projects) as well as identification of any unique capabilities
- A comparison of the research performance and overall research capabilities of the laboratories with those of universities and industrial laboratories doing similar work
- A comparison of laboratory capabilities in project management with those of federally funded research and development centers.

Considering the multiplicity of research and development efforts carried out by the laboratories, it was obviously impossible for the Panel to assess systematically even representative samples of the efforts. Fortuitously, the Office of Energy Research recently completed a systematic evaluation of the Basic Energy Science (BES) program consisting of a sample of 129 projects (randomly selected to represent the balance among disciplines from a list of over 1200 completed projects) whose research results were in each case reviewed by panels of specialists. This study was carefully carried out by 180 reviewers from industry, universities, laboratories, and other affiliations (78% of which were from outside the laboratories) thus permitting reasonably objective comparisons of similar efforts carried out in the laboratories and in universities. The BES projects were selected from a range of disciplines in physical, chemical, biological, and engineering sciences that are representative of much of the research and development capabilities of the laboratories. The statistically analyzed results of this study show that laboratory performance compares very favorably with that of universities.

It must be cautioned that the BES program represents only roughly 5% of the efforts of the laboratories under study, and the projects were all relatively small compared with the sizes of projects represented in many other laboratory efforts. While the conclusions of the BES study are reasonably extended to all supporting research and possibly also to general science and environment categories, extrapolation of conclusions to the larger categories of effort (e.g., nuclear, magnetic fusion, and nonweapons defense activities) or to the somewhat smaller categories of energy technology efforts (solar, fossil, conservation, etc.) may be questioned. The Department may wish to carry outcomparable studies in other areas.

The Panel wishes to point out that it is not the *quality* of the laboratory work that is usually questioned; rather, most critical questioning seems to be directed at the appropriateness of what the laboratories have been doing. For example, Dr. Arthur Bueche's testimony for Congressional Committee hearings on "DOE national laboratory relationships with industry and the university community" and his answers to supplemental questions asked by the Committee concerned primarily the balance of work assignments among performers and the standards of utility by which energy research and development results should be judged. Thus, it may be that issues of mission appropriateness and concerns about a perceived overdiversification of the laboratories in recent years may have raised implicit questions about whether the laboratories output in some areas, while technically sound, has been ill-conceived or poorly managed.

This observation, together with discussions with the Department's Headquarters and operations office staffs, significantly supplemented by detailed discussions at each of the laboratories with the Directors and their senior staff, led the Panel to question whether the existing institutional arrangements respecting the Department's organization and management of the laboratories may in themselves be the most significant impediment to optimal utilization of the scientific and technological capabilities of the laboratories. One of the indicators of such an impediment is that the laboratory directors have rather little control over the research and development activities of their own laboratories. The totality of each laboratory's program is primarily the result of individual negotiations between Headquarters and the laboratories at individual staff levels rather than at management levels. By the same token, the Department's management has relatively little control over laboratory activities except through gross budget actions at highly aggregated program levels.

The Panel finds the Department's management of the laboratories in practice is highly disaggregated, a condition further exacerbated by layering and fractionation of research and development responsibilities. Prolonged budgetary and appropriations uncertainty and the pressure of repetitive crash readjustments in program priorities create an environment in which it would be easy for the laboratory to lose its sense of basic mission and its ability to effectively transfer technology, and thus to enter into fields not appropriate for Federal support.

The Panel is impressed by laboratory accomplishments, which are summarized in Attachment C. The Panel further finds, however, that full realization of the laboratories' capabilities requires new institutional arrangements as delineated below.

### C. Findings and Recommendations

#### 1. Findings

- Overall, the Panel finds the scientific and technological capabilities of the laboratories impressive, but DOE organizational inefficiencies and funding policies are obstacles to their full realization.
- The Panel is uniformly impressed with the qualities and resourcefulness of laboratory leadership.
- The scientific and technical resources of the laboratories, including their physical facilities, cannot be utilized effectively under prolonged budgetary uncertainty and the pressure of repetitive crash readjustments in program funding.
- Layering and fractionation of managerial and research and development responsibilities in DOE require the laboratories to interact with DOE on an excessive number of horizontal and vertical levels and with heavy reliance on negotiation. The absence of a coordination and resolution officer with full authority at the Headquarters level giving attention and support to the laboratory directors results in inefficient utilization of laboratory scientific and technical capabilities.

#### 2. Recommendations

- Urge the Office of Management and Budget to support rolling two-year appropriations by Congress for research and development with carry over funding to stabilize Department and laboratory planning and program execution.
- Designate a high level official, such as a Deputy Undersecretary whose sole function is to be the Chief Laboratory Executive with authority to help determine and defend the research and development budget; to allocate the resources; to decide where work is to be done; and to assess laboratory scientific, technical, and managerial performance.
- Consistent with the foregoing, modify the roles of the operations offices with respect to the laboratories to focus on management of the contracts with the laboratory operating contractors and to de-emphasize their function as policy and programmatic intermediaries between Headquarters and the laboratories.
- Arrange for the laboratory directors to have substantially more flexibility, within overall budgets and broad program guidelines, to reprogram assigned laboratory resources and to initiate or adapt programs in accordance with research and development opportunities. This reprogramming authority should be no less than 5% or more than 10% subject to the satisfactory completion of the original assigned program acitivity. If additional Congressional authorization for this reprogramming is needed, the Department should seek it.

# VI. THE DEPARTMENT'S POLICIES AND PROCEDURES WITH RESPECT TO THE LABORATORIES

Under U.S. laws and the laboratories' operating contracts, the potential scope of the laboratories is quite broad, encompassing health and safety research and all areas of nuclear and nonnuclear energy and environmental research and development. DOE policies, however, have set limits on what is considered as appropriate work for the laboratories.

For purposes of contract administration, the DOE field operations offices oversee the laboratories. Thus, the Chicago Operations Office is contract administrator for Ames Laboratory, Argonne National Laboratory, and Brookhaven National Laboratory; Albuquerque Operations Office, for Los Alamos National Laboratory and Sandia Laboratories; Oak Ridge Operations Office, for Oak Ridge National Laboratory; San Francisco Operations Office, for Lawrence Berkeley Laboratory and Lawrence Livermore National Laboratory; and Richland Operations Office, for Pacific Northwest Laboratory.

For purposes of programmatic and institutional management, the laboratories report to the Director of Energy Research or to the program Assistant Secretary who funds the major share of the laboratory work. Thus, the Director of Energy Research is the "cognizant secretarial officer" for the Ames, Argonne, Brookhaven, Oak Ridge, and Lawrence Berkeley laboratories; the Assistant Secretary for Defense Programs, for the Los Alamos, Lawrence Livermore, and Sandia laboratories; and the Assistant Secretary for Nuclear Energy, for the Pacific Northwest Laboratory.

## A. Management Policies and Procedures

**The Institutional Planning Process.** To manage this unique set of multiprogram laboratories, the Department employs several management processes. The basic strategic planning vehicle is the Institutional Plan. This is a long-range planning document through which the Director of Energy Research or the Assistant Secretaries for Defense Programs and Nuclear Energy, the other program Assistant Secretaries sponsoring work, the responsible operations office, and the laboratories reach agreement on the general types and levels of activity to be conducted at each laboratory through a five-year planning period. The plan is updated annually and is approved by the appropriate secretarial officer and reviewed by the Under Secretary. The approved plan provides guidance to the laboratory for long-range planning and budget preparation and for site development plans. In addition, it serves as the baseline for placement of work at the laboratory.

Another of the Department's management processes is the periodic appraisal of laboratory performance, both technical and administrative. The Department also makes an annual assessment of requirements for maintaining the laboratory physical plant and endeavors, through the budget process, to accommodate identified needs.

**The New Work Assignment Procedure.** Supplementing the Institutional Plan process is a new work assignment procedure for considering placement of types or levels of work at the laboratories not contemplated at the time of preparation of the Institutional Plan. Such requests are approved by an official at the assistant secretary level and/or the responsible operations office after evaluation of the suitability of placing the work at a laboratory as opposed to universities or industry and the suitability of the particular laboratory for conducting the work. It is DOE policy to give preference to the private sector in the assignment of work it is qualified to perform. However, because DOE contracting procedures are cumbersome, new work is sometimes awarded to a laboratory as a matter of contractual convenience.

The Panel notes in this regard that neither the Institutional Plan process nor the new work assignment procedure provides a means of assessing the suitability vis-à-vis university and industry capabilities of ongoing work at the laboratories that was initiated prior to the adoption of these management processes.

**Policies on Work for Others.** The laboratories are permitted, sometimes encouraged, and in certain cases (e.g., Nuclear Regulatory Commission) required to do work for other government agencies. Interagency agreements are set up between DOE and the agency requesting the work.

DOE policies on work for other Federal agencies are given in DOE Order 4300.2, which specifies the following restrictions on non-DOE work: (1) it must be determined that private facilities and laboratories are not available to perform the work on a convenient basis and at a reasonable cost; (2) the non-DOE work will not interfere with DOE program activities; and (3) the work must be consistent with DOE's basic responsibilities.

The laboratories are also cautioned not to respond to requests for proposals open to the private sector.

Although other agencies have the statutory authority to request work from DOE, some agencies' policies may actually constrain the laboratories from receiving funds. For example, the *National Science Foundation Grant Policy Manual* (201.1d) specifies that in

> . . .carrying out its statutory purposes, NSF is expressly authorized by its own statutory authority to support research performed by other Federal agencies. However, it presently is Foundation policy not to encourage research proposals from other Federal agencies except in pursuit of specific NSF objectives.

**Policies on Technology Transfer.** DOE's technology transfer policy implementing the Stevenson-Wydler Technology Innovation Act of 1980 is established in DOE Order 5800.1, "Research and Development Laboratory Technology Transfer Program," issued from Headquarters on March 25, 1982. This order requires the laboratories to conduct technology transfer activities including:

> a) assessement of R&D projects for applicability to the needs of the private sector and state and local governments; (b) application and/or adaption of research or technology into processes, products, and services for use by private sector and state and local governments; (c) technical assistance to the private sector and state and local governments in adapting federally developed technology for use; (d) cooperation with technology transfer brokers to move technology from the laboratories to the private sector and state and local governments; and (e) licensing of DOE-owned patent technology for commercial use.

Each laboratory is required to formulate an annual five-year technology transfer program plan and make an annual technology transfer program report.

It is too early to tell whether the Stevenson-Wydler Act will significantly increase technology transfer between the national laboratories and other sectors. At a minimum, the act requires the Government and its laboratories to put a high priority on technology transfer activities.

### B. Assessment of Policies and Procedures

It is not an overstatement that the Department's approach to the laboratories can be characterized as micromanagerial in administrative and procedural matters and quite conservative in its policy constraints on the permitted scope of laboratory activities.

In the former area, the Panel recognizes that there are certain fundamental Federal requirements that must be accommodated and that certain of these derive from the Office of Management and Budget and the Congress. Nevertheless, the Panel finds it disturbing that Argonne National Laboratory, for example, is required to be responsive to 137 different DOE orders and policy issuances, entailing dedication of substantial manpower and funding for compliance, reports, and audits. Equally disturbing is the fact that Argonne receives its funding through 129 separate accounts which are noninterchangeable and require separate controls.

Micromanagement to this degree deprives the laboratory of virtually all flexibility for better management of its resources. Moreover, it results in a significant diversion of laboratory resources from research and development missions. In substance, it deprives the Department of the very benefits and advantages that the government owned contractor operated mode of operation is designed to provide.

Policy constraints upon the laboratories in general are less onerous but nonetheless counterproductive. These constraints lie primarily in the area of laboratory relationships with the private sector and thus adversely affect technology transfer. For example, Departmental policies either preclude or overly limit laboratory work for others, private consulting by laboratory employees, and laboratory responsiveness in appropriate circumstances to government sponsored requests for proposals. Undue restrictions on laboratory work for others, in particular, are counter productive to national technological interests. The scientific and technological capabilities of the laboratories, developed to a high degree of sophistication at public expense over several decades, can contribute significantly beyond the primary laboratory mission responsibilities to other critical areas of national needs supportive of increased innovation, productivity, and international competitiveness. Within reasonable limits, greater accessibility by others to the laboratories for such additional purposes would represent prudent use of this important component of the national technological enterprise.

In certain areas, it must be said in fairness the Department has made important strides. For example, with respect to appraisal of laboratory performance, which has been somewhat loosely implemented in recent years, the ongoing effort to develop a Departmentwide systemized and codified appraisal procedure with appropriate management follow-up, when completed and implemented, should result in benefits to both the Department and the laboratories. Also, the recently issued class waiver of patent rights in the case of fully cost reimbursed private use of laboratory facilities is a significant advance, assuming it is vigorously pursued at the operations office level. Moreover, the recent DOE Order on technology transfer at least establishes this function as a formal part of the Department and laboratory mission, albeit no dedicated funding appears to be forthcoming as will be necessary if such a function is to become fully operational. The implementation and maturation over the past few years of the laboratory institutional planning process also has been a beneficial initiative. It offers some degree of desirable long-range research and development program planning at the laboratories, although the Panel notes that the tendency to employ the Institutional Plans as constraining budget documents rather than strategic planning vehicles needs to be resisted.

## C. Findings and Recommendations

### 1. Findings

- The laboratories have become grossly overburdened with detailed reporting and other paperwork requirements, the utility of which frequently is not apparent and which unnecessarily divert resources from their research and development missions.
- The Department's laboratory Institutional Planning Process is proving itself valuable, both to DOE Headquarters and the laboratories, although care needs to be taken that it produces a workable plan and not a strait jacket.
- The Department's approach toward appraising laboratory performance has been somewhat lacking in systemization, codification, and management follow-up. The Panel is pleased to note that the Department is in the process of rectifying this situation.
- The Department's restrictions on laboratory work for others, particularly industry, are unnecessarily constraining. Among other things, such restrictions frustrate technology transfer efforts.
- The Department's patent policy, particularly in connection with laboratory work for others, has been among the salient barriers to cooperative relationships with industry and to effective technology transfer. The Panel notes with approval that the Department recently has taken steps to liberalize its policy in this area.

### 2. Recommendations

- Utilize the services of an outside audit contractor familiar with both Government and industry practices to conduct a thorough audit of paperwork requirements in the Headquarters/operations offices/laboratory chain of command.
- Strengthen laboratory Institutional Plans as long-range strategic planning documents, as components of the Department's planning process, and as vehicles for new initiative proposals; de-emphasize their use as constraining budget documents.
- To supplement internal appraisals of laboratory performance, the Department should convene panels from recognized scientific bodies, such as the National Academies of Science and Engineering, to conduct periodic (at intervals not greater than five years) technical audits of laboratory programs in connection with approved institutional plans.
- While maintaining priority status for essential Department missions, allow the laboratories to do more reimbursable work for others (other Federal agencies, state and local governments, and industry) be relaxing constraints on such work.
- Undertake a well-planned education program among Headquarters, operations office, and laboratory staff on the recently liberalized patent policy to ensure that it will be vigorously implemented. In parallel, ensure that the private sector understands the new policy.

# VII. THE EFFECTIVENESS OF THE DEPARTMENT'S USE OF THE LABORATORIES IN MEETING ITS ENERGY OBJECTIVES

The Department's effectiveness in making use of its laboratories is strongly conditioned by the roles and missions perceived for the laboratories, the organization and management arrangements for fully realizing the scientific and technological capabilities of the laboratories, and the Department's policies and procedures with respect to the laboratories.

## A. Assessment of Effectiveness

In some respects, it appears the Department has been rather conservative in utilizing the laboratories' capabilities. For example, although the laboratories constitute an exceptional reserve of scientific and technical knowledge and expertise, in recent years the Department has made little or no use of their capability in Departmental research and development policy and planning. Participation of the laboratories in a consultative capacity in these respects would add an invaluable knowledge dimension to the Department's resources for these purposes.

Through overmanagement and underutilization, the Department has deprived itself and the nation of the best that the laboratories have to offer. In principle the Department adopted the laboratory lead mission concept and the concomitant policy of decentralization; in practice it prejudiced the concept through excessive fractionation of programs and vitiated the policy through inadequate delegation of program execution authority to the laboratories.

Whereas the Department made credible and often successful efforts to create important, highly capital intensive research facilities of national and even international significance, it chooses or is required to fund their operation at levels far lower than those commensurate with their capabilities. In FY 1982, for example, the utilization factor for high energy physics machines ranges from 40% to 45%.

The Department (and the Administration) recognizes the appropriate Federal role in and adequately supports long-range, high-risk potentially high-payoff research and development; however, it limits or precludes as a matter of policy the kinds of close relationships between the laboratories and industry that are necessary if the benefits of such research and development are to be practically realized. Thus, Departmental and national energy research and development objectives would be advanced if policy and procedural avenues were developed by which the laboratories could engage in joint ventures with industry involving test and pilot demonstrations. Similarly, permitting the laboratories to engage with industry in jointly or cooperatively responding to Federal agency technical requests for proposals would better ensure that Federal technical needs benefit from application of the broadest possible spectrum of national scientific and technical expertise. It is recognized that laboratories must participate fairly in vying with the private sector for government work and, therefore, that costing of laboratory work for these purposes must be calculated as nearly as possible on the same bases as is done in industry.

The Department also recognizes the role the laboratories can play in the education and training of scientists and engineers, but it does not exploit this capability to the full extent possible.

In the last analysis, effective use of the laboratories in technology areas is reflected most accurately by the success or lack thereof in the application of the results of laboratory research and development in the marketplace. Issuance of the DOE Order on technology transfer is a significant, but not sufficient, step in the right direction. A major management commitment, backed up by adequate resources, is required. Effective technology transfer is extremely difficult to achieve under the best circumstances. Even if the laboratories were exceptionally well attuned to this function (and they are not), extraordinary efforts will still be necessary to achieve even modest success. Complicating the problem is the fact that the multiprogram laboratories, along with other government laboratories, are constrained by traditional governmental policies and attitudes that inhibit effective technology transfer. Often government laboratories are not permitted to pursue research and development sufficiently far to establish reasonable evidence of technical and economic feasibility and thus to create private interest. Even if they are, industry often has great difficulty in obtaining the patent protection needed to justify its required further development and commercialization investment, a consideration that strongly inhibits effective technology transfer. The traditional arms-length relationship between government and industry is intrinsically an obstacle to effective technology transfer.

The Department must do much more to seek out and implement measures that will materially facilitate the technology transfer process.

### B. Findings and Recommendations

#### 1. Findings

- The Panel finds that the Department has been conservative in envisioning, not to mention implementing, policies by which the laboratories could be more effectively utilized. This has resulted in a lesser contribution by the laboratories toward meeting the Department's energy objectives than could otherwise be achieved.
- Contrary to past practices, the expertise of laboratory staff and directorate are not being utilized in establishing Department policy and directions for research and development.
- While laudable in principle, the Department's policy of assigning lead missions to the laboratories, has been, with few exceptions generally ineffective because of excessive fractionation of mission assignments, inadequate delegation of authority to the laboratories, and seeming lack of commitment to the policy by DOE management.
- Under present budgetary constraints a number of the specialized research facilities at the laboratories are being operated far below capacity.
- While use of the laboratories for contributing toward training scientists and engineers to meet the Nation's needs has grown in recent years, their use could increase.
- Research and development program planning does not consider adequately end-user views.
- Institutional and doctrinal barriers toward greater laboratory/industry cooperation continue to inhibit achievement of the Department's energy objectives in general and technology transfer efforts in particular.

#### 2. Recommendations

- Establish a consultant group composed of all the laboratory directors to utilize more effectively laboratory resources in establishing the Department's research and development policy and directions.
- Implement vigorously the assignment of lead missions to the laboratories, defining these in terms of major applied programmatic missions, and provide for significantly greater laboratory discretion in allocation of resources (within overall Headquarters established budgets for the mission area) and in the selection of performers.
- In setting research priorities, give special weight to making optimal productive use of sophisticated equipment and facilities.
- Establish user groups reporting to the Department, similar to the High Energy Physics Advisory Panel and the Nuclear Science Advisory Committee, for all of the Department's major mission programs and facilities. These could be established independently for each program function or under the umbrella of an overall advisory group.
- Continue to support laboratory/university cooperation in the training of scientists and engineers through on-site participation by faculty and student in laboratory programs, term appointments, fellowships, etc.
- Permit and encourage joint ventures in selected projects with industry, including test and pilot demonstration (located at the laboratories or on industrial sites) in order to test economic feasibility and to shorten the time lag for technology transfer.
- In areas of special laboratory expertise and capabilities, allow and encourage the laboratories to work more closely with industry by such means as responding to requests for proposals from industry cooperative groups (e.g., American Society of Heating, Refrigeration and Air-Conditioning Engineers; Electric Power Research Institute; and Gas Research Institute) and to work in partnership with industry in meeting technical needs of Federal agencies, as well as working directly for industry in connection with Federal agency requests for proposals.
- Permit each laboratory to use 1% to 2% of its capital and operating budget for independent research and development at the discretion of the laboratory director in order to enrich their research capabilities.
- Through a deliberate review and study by both the Department and the laboratories, identify institutional and doctrinal barriers to effective technology transfer and implement further actions to ameliorate these.

# VIII. ALTERNATIVE STRATEGIES FOR MAKING BEST USE OF THE LABORATORIES IN A CONSTRAINED BUDGETARY ENVIRONMENT

## A. Asssessment of Strategies

In its March 1982 Preliminary Report, the Panel identified strategies, to be further studied, for making best use of the laboratories in a constrained budgetary environment. In the course of its deliberations, the Panel concluded that two of these, the lead mission policy and freeing the laboratories to do much more work for others, had validity in their own right as contributors to more effective use of the laboratories. These have been discussed earlier. The other strategies envision preferential assignment to the laboratories of new research tasks in lieu of establishing new laboratories for these tasks, transfer to the laboratories of work presently franchised to other agencies, and shutting down or merging laboratories.

The Panel can see no justification currently or in the long run for the Department to establish new laboratories. The other two strategies present some benefits but also substantial risks.

Transferring work currently franchised to other agencies offers benefits in terms of more direct control over mission-supporting research, avoidance of bureaucratic interagency problems, and increased work volume to justify adequate staffing. Risks arise from vested laboratory interests in gaining new work at the expense of siting it in a better environment; from disruption of other agency programs; from possibly higher net costs compared with franchising; and from favoring the laboratories versus employing a highest- and best-use approach to the placement of Federal research work within the larger governmental system.

The benefits of shutting down or merging laboratories are mainly financial, with savings in operating expenses and overhead. The risks are various: irreversibility of decisions to terminate or consolidate; political controversy; adverse morale; possible undeserved termination of certain lines of research; negative impact on university and other present users of unique facilities; and consequences of accommodating to a forcing strategy for budgetary reasons at the expense of long-term expectations for a functioning and diversified laboratory system.

These latter strategies are viewed as drastic and to be considered only as a last resort.

## B. Findings and Recommendations

### 1. Findings

- Some of the laboratories are currently being funded at levels close to the minimum consistent with maintaining their present competence and vitality.
- In view of their current broader responsibilities, any further funding reductions that would reduce laboratory staffing below the levels of the mid-1970's would demand that a number of measures, some drastic, be considered to preserve as much as possible the scientific and technical assets of the laboratory complex.

### 2. Recommendations

Certain measures that would help stabilize the laboratory complex in the event of further budgetary reductions have validity in their own right as contributors toward more effective use of the laboratories. These measures, which have been addressed earlier, relate to the lead mission policy and the freeing of the laboratories to do much more work for others. Additional measures recommended for consideration if necessary include:

- Transferring appropriate DOE-sponsored work now performed by other Federal agencies and directing additional work into the laboratories by assigning to them those new tasks for which new laboratories might otherwise be established.
- Narrowing the missions of the laboratories to correspond to the resources available.
- Closing particular laboratories or merging one or more of them with other DOE laboratories or even with other appropriate institutions outside the Department.

# IX. ADDITIONAL CONSIDERATIONS

The Panel's Preliminary Report identified a number of issues to be addressed in the Final Report, most of which are covered in the Findings and Recommendations. This Section discusses those remaining issues not otherwise addressed in this Report.

## A. Appropriate Size of the Laboratory Complex

As the Department's mission changes, it is reasonable to ask how large the laboratory complex should be and whether spending half of the entire DOE budget for research and development through the laboratories is still appropriate.

In FY 1981, about 51% of the Department's research and development budget went to the multiprogram laboratories, whereas only 33% went to industry and universities. On the face of it, the heavy reliance of DOE on its internal laboratories appears to be an anomaly when compared with the degree of internal spending of other Federal agencies. For example, the National Institutes of Health spend more than 90% of their budget externally. The anomaly is, however, more apparent than real. The reasons for the perceived difference can be found in the laboratories' involvement in the weapons programs and in the use of the multiprogram laboratories as conduits for DOE funding of industry and universities.

Over 42% of the multiprogram laboratories' funding in FY 1981 was for nuclear weapons, an area that seems inappropriate for industry and universities. If consideration is limited to DOE's energy research and development work, the multiprogram laboratories received approxi-mately 28% of DOE's budget, whereas industry and universities received 44%. But the multiprogram laboratories' share was actually less than 28% because of pass-through funds.

About 39% of the multiprogram laboratories' total operating budgets in FY 1981 was used for subcontracts and external procurement; most of this money went to industry and universities. Thus, the laboratories' in-house energy research and development probably amounts to no more than 20% of DOE's energy research and development budget. Considering the capabilities of the multiprogram laboratories for performing the long-term, high-risk energy R&D appropriate for Federal funding, it would appear that DOE has not made excessive use of its laboratories. With the trend to more defense spending and to fewer technology demonstrations, it is likely, and reasonable, that a larger percentage of the DOE budget will go to its multiprogram laboratories in the future.

## B. Suitability of Agency Work Assignments to the Laboratories, Universities, and Industry

The Agency's laboratory Institutional Planning Process and New Work Assignment procedures are designed in part to control research and development activities assigned to the laboratories vis-à-vis universities and industry in accordance with prescribed criteria. The New Work Assignment procedure appears to accomplish this purpose for ad hoc proposals arising in the course of time. The Institutional Planning Process, however, appears to address this issue only at the margin (i.e., with respect to new work considered at the time the annual Institutional Plans are being developed). It therefore appears that there is no mechanism or process by which work ongoing at the laboratories over long periods of time (predating the foregoing processes and procedures) is reviewed for suitability for universities and industry in light of current circumstances.

Individual assignments to the laboratories are accomplished by a Work Proposal and Authorization System or another comparable mechanism. Review of these documents would provide a means of assessing current suitability of work assignments to the laboratories and should be done.

## C. Effects on the Laboratories If the Board's Recommendations Detailed in the Federal Energy R&D Priorities Report Were to Be Implemented

The Panel's original intention to examine this matter was overtaken by programmatic and budgetary events; hence, it was determined such an analysis would not be useful.

# ATTACHMENT A

# DEPUTY SECRETARY'S CHARGE

THE SECRETARY OF ENERGY
WASHINGTON, D.C. 20585

Mr. Louis H. Roddis, Jr.
Chairman
Energy Research Advisory Board
110 Broad Street
Charleston, South Carolina 29401

Dear Mr. Roddis:

The multiprogram laboratories of the Department of Energy are an important national resource and play a key role in accomplishing the Department's missions. The Department is presently committed to focus its efforts on long-term, high-risk energy research and development and must adjust to an increasingly austere budget. Under these circumstances, I am concerned that the scientific and technical strength of the laboratories may be eroded and that their ability to continue to contribute to the Nation's long-range energy needs may be diminished.

Although the Energy Research Advisory Board is addressing the overall Federal role in energy R&D in your study of R&D priorities, the specific roles and missions of the multiprogram laboratories within this framework have not been examined. Therefore, I would appreciate the Board undertaking a comprehensive study that will help shape the future of the Department's multiprogram laboratories. I am particularly interested in your review, appraisal and recommendations regarding the scientific and technological capabilities of the laboratories, the appropriate roles and missions of the laboratories vis-a-vis industry and the universities, the Department's policies and procedures with respect to the laboratories, and the effectiveness of the Department's use of the laboratories in meeting our energy objectives. I fully expect additional questions to arise related to the laboratories and would appreciate interim reports as your study progresses, with one by March 1, 1982, giving preliminary recommendations.

A final report should be completed by September 1982. I realize that this is a major undertaking in addition to the Board's current efforts, but request that you give it a high priority. You can be assured of the full cooperation and assistance of the Department.

By copy of this letter, I am requesting the Director of the Office of Energy Research, the Assistant Secretaries, Operations Office Managers and multiprogram laboratory Directors to give you their fullest cooperation and support. The Board's efforts should also be coordinated with the Director of the Office of Energy Research who will provide the necessary resources for the study and will be conducting additional related reviews at my request.

Sincerely,

Ken

W. Kenneth Davis
Deputy Secretary

cc:
Director, Office of Energy Research
Assistant Secretaries
Managers, DOE Operations Offices
Directors: Ames Laboratory
  Argonne National Laboratory
  Brookhaven National Laboratory
  Hanford Engineering Development Laboratory
  Idaho National Engineering Laboratory
  Lawrence Berkeley Laboratory
  Lawrence Livermore National Laboratory
  Los Alamos National Scientific Laboratory
  Oak Ridge National Laboratory
  Pacific Northwest Laboratory
  Sandia National Laboratories
  Savannah River Laboratory

# ATTACHMENT B

# CAPSULE SUMMARIES
# OF
# THE DOE MULTIPROGRAM LABORATORIES

Ames Laboratory
Argonne National Laboratory
Brookhaven National Laboratory
Lawrence Berkeley Laboratory
Lawrence Livermore National Laboratory
Los Alamos National Laboratory
Oak Ridge National Laboratory
Pacific Northwest Laboratory
Sandia Laboratories

## AMES LABORATORY
### Ames, Iowa

The Ames Laboratory conducts basic research in materials and chemical sciences relying upon existing capabilities for preparing high purity metals, alloys, compounds and single crystals, and conducts materials related research and development in areas such as nondestructive testing of materials. Smaller but unique and vigorous capabilities are maintained in high energy physics, nuclear physics, applied mathematics, coal preparation science, and solar technology. The laboratory enjoys extensive cooperations with Iowa State University through year-round faculty appointment, graduate student training, and facilities sharing programs. An effective summer research participation program for undergraduate students and faculty members (primarily from non-local institutions) is maintained by the laboratory to the mutual benefits of it, the participants, and their institutions. The Ames Laboratory actively disseminates the results of its work throughout the scientific and technological communities by the distribution of technical publications, the giving of invited presentations on technologically important topics, the consulting activities of laboratory staff members, the conduct of cooperative projects with industrial and other governmental concerns, and participation in the Federal Laboratory Consortium.

| **Statistics:** | **FY 1982 (Estimated)** |
|---|---|
| DOE Operating Budget Costs: | $15 M |
| Staffing (Full-Time Equivalent): | 427[1] |
| Capital Investment (Plant and Equipment): | $31 M[2] |
| Number of Acres: | 56 |

**Operating Contractor:** Iowa State University

**Responsible Operations Office:** Chicago Operations Office

**Principal Program Activities (FY 1982 Estimated):**[3]

Materials Sciences (42%)
Chemical Sciences (19%)
Fossil Energy (11%)
Biological and Environmental Research (5%)
High Energy Physics (4%)
Nuclear Physics & Nuclear Sciences (2%)
Engineering, Mathematical & Geosciences (2%)
Univeristy Research Support (2%)
Nuclear Energy (1%)
Miscellaneous DOE Programs (5%)[4]
Work for Others (6%)
  Nuclear Regulatory Commission (1%)
  Department of Defense (3%)
  Others (2%)

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[1] Total Laboratory Staff.
[2] Current Book Value.
[3] Percentages reflect direct staff (full-time equivalent).
[4] Programs less than 1% are aggregated in this category.

## ARGONNE NATIONAL LABORATORY
### Argonne, Illinois

The Argonne National Laboratory (ANL) provides advanced nuclear technology research and developmental support to the breeder reactor and other fission reactor programs, and maintains a substantial, diversified capability in physical and biological sciences in support of reactor efforts. Future efforts in the fossil area center on advanced process development, the materials technology, and instrumentation and controls systems engineering. In basic research, the largest effort is in the area of general materials studies. High energy physics and nuclear physics will continue to play a significant role.The consequences of the utilization of particular energy technologies are addressed through studies of health-related problems and the environment. The laboratory has a program to work closely with university professors on sabbatical leaves and sponsors a variety of programs providing opportunities for students through student-laboratory staff interaction.

Argonne is engaging in a number of activities aimed at improving industrial interactions, including involvement in the joint IRI/National Laboratory Task Force, as well as others.

| Statistics: | FY 1982 (Estimated): |
|---|---|
| DOE Operating Budget Costs: | $210 M |
| Staffing (Full-Time Equivalent): | 4,538 |
| Capital Investment (Plant and Equipment): | $545 M[1] |
| Number of Acres: | 2.245 |

**Operating Contractor:** The University of Chicago in cooperation with the Argonne Universities Association

**Responsible Operations Office:** Chicago Operations Office

**Principal Program Activities:**

Nuclear Energy (36%)
Basic Energy Sciences (17%)
Conservation and Renewable Energy (9%)
Biology (7%)
Fossil Energy (6%)
High Energy Physics (3%)
Nuclear Physics (3%)
Environmental Protection, Safety, and Emergency Preparedness (2%)
Fusion (2%)
Defense Programs (1%)
Work for other DOE (1%)
Miscellaneous DOE Programs (2%)
Work for Others (11%)
  Nuclear Regulatory Commission (5%)
  Department of Defense (1%)
  Others (5%)

**Major Active Facilities:**

Experimental Breeder Reactor II
Hot Fuels Examination Facilities
TREAT Reactor
Zero Power Reactors
Zero Power Plutonium Reactor

**Major User Facilities:**

Intense Plused Neutron Source I
Facility for High Resolution Atomic Spectroscopy
Argonne Tandem Linac Accelerator

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[1] Includes Argonne National Laboratory West, Idaho.

## BROOKHAVEN NATIONAL LABORATORY
### Upton, New York

The Brookhaven National Laboratory (BNL) conceives, develops, constructs, and operates complex large research facilities which are used to study fundamental properties of matter and are shared with university and industrial scientific communities (e.g., the National Synchrotron Light Source and the Alternating Gradient Synchrotron). The laboratory conducts basic and applied research in technology base areas, in support of research facilities, and to discover important new directions for research. Major disciplinary strength is found in the areas of high energy, nuclear and solid state physics, chemistry, and biology. Biological and medical programs include studies of the effects of radiation and of chemical substances involved in the production and use of energy. Other research programs include meteorological dispersion, atmospheric chemistry, pulmonary physiology, and inhalation toxicology. The National Synchrotron Light Source gives the laboratory a unique position in the breadth of sophisticated facilities available to all areas of the physical and biological sciences. Over 1,000 faculty and 160 students have guest appointments enabling them to carry out research at BNL facilities. In addition, there are five different programs which provide 150 students with a variety of training opportunities. The National Synchrotron Light Source will greatly increase the number of faculty and students carrying out research programs at the laboratory. This facility will also be used extensively by industrial scientists; presently, nine of the 29 initial beam lines at the facility are partially or completely supported by the industrial community.

| **Statistics:** | **FY 1982 Estimated:** |
|---|---|
| DOE Operating Budget Costs: | $125 M |
| Staffing (Full-Time Equivalent): | 3,300 |
| Capital Investment (Plant and Equipment): | $469 M |
| Number of Acres: | 5,265 |

**Operating Contractor:** Associated Universities, Inc.

**Responsible Operations Office:** Chicago Operations Office

**Principal Program Activities (FY 1982 Estimated):**

- High Energy Physics (39%)
- Basic Energy Sciences (19%)
- Environmental Research and Development (6%)
- Life Sciences Research and Nuclear Applications (5%)
- Nuclear Physics (3%)
- Miscellaneous DOE Programs (10%)
- Work for Others (18%)
  - Nuclear Regulatory Commission (9%)
  - Others (9%)

**Major Active Facilities:**

National Synchrotron Light Source
Alternating Gradient Synchrotron
High Flux Beam Reactor
Tandem van de Graaff

**Major User Facilities:**[1]

60" Cyclotron
Scanning Transmission Electron Microscope
Central Scientific Computing Facility
Research Hospital

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[1] In addition to those facilities listed under Major Active Facilities column.

## LAWRENCE BERKELEY LABORATORY
## Berkeley, California

The Lawerence Berkeley Laboratory (LBL) conceives, develops, constructs, and operates complex large research facilities which are shared with university and industrial scientific communities (e.g., Bevalac and Super HILAC). The laboratory capitalizes on its co-location with the University of California to provide a broad range and flexible pool of the scientific talent for research and advanced development with major research programs in high-energy physics, nuclear physics, basic energy sciences, conservation and solar energy, coal research, interial confinement fusion, geochemistry, computer science, and mathematics. LBL has a role in the training of the next generation of scientists and engineers for careers in advanced energy research and technology. Over 500 resident graduate students conduct thesis research at the laboratory and many more use its facilities or perform collaborative research. Participation in energy research programs provides these students with skills in high demand by energy industries. The flow of Ph.D.'s to industry is one of many forms of technology transfer that allows LBL to maintain close and supportive relationships with industry.

| **Statistics:** | **FY 1982 (Estimated):** |
|---|---|
| DOE Operating Budget Costs: | $84 M |
| Staffing (Full-Time Equivalent): | 2,524 |
| Capital Investment (Plant and Equipment): | $195 M |
| Number of Acres: | 70[1] |

**Operating Contractor:** The Regents of the University of California

**Responsible Operations Office:** San Francisco Operations Office

**Principal Program Activities (FY 1982 Estimated):**

Energy Research (67%)
Conservation & Renewable Energy (8%)
Fossil Energy (2%)
Miscellaneous DOE Programs (4%)
Work for Others (19%)
  Nuclear Regulatory Commission (4%)
  Department of Defense (2%)
  Other (13%)

**Major Active and User Facilities:**

Bevatron
Super HILAC
88" Cyclotron
High Speed Computers

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[1] Leased to the Government.

## LAWRENCE LIVERMORE NATIONAL LABORATORY
### Livermore, California

The primary role of Lawrence Livermore National Laboratory (LLNL) is the research, development, and test of nuclear weapons designs. Expertise developed in this area is also supplied to related areas of defense research such as inertial confinement fusion, nonnuclear ordnance, and particle-beam technology. LLNL also undertakes research and development technologies of national interest, primarily in the field of energy, where the skill or facilities requirements are unique and synergistic to the on-going weapons effort. As a result the Laboratory has active on-going programs in magnetic fusion energy, laser isotope separation, biomedical and environmental studies, in-situ coal gasification and oil shale retorting, energy storage systems, transportion energy conservation, and solar energy research and development. Within these programs, LLNL interacts with both universities and private industry through faculty/student training, consulting, and technology transfer activities.

| **Statistics:** | **FY 1982 (Estimated):** |
|---|---|
| DOE Operating Budget Costs: | $450 M |
| Staffing (Full-Time Equivalent): | 7,200 |
| Capital Investment (Plant and Equipment): | $445 M[1] |
| Number of Acres: | 631 |

**Operating Contractor:** University of California

**Responsible Operations Office:** San Francisco Operations Office

**Principal Program Activities (FY 1982 Estimated):**[2]

Defense Programs (51%)
Magnetic Fusion (10%)
Laser Fusion Energy (10%)
Isotope Separation (6%)
Energy Programs (3%)
Biomedical/Environmental (3%)
Miscellaneous DOE Programs (3%)
Work for Others (14%)
  Department of Defense (8%)
  Nuclear Regulatory Commission (3%)
  Other Federal Agencies (3%)

**Major Active Facilities:**[3]

Argus Laser Facility
Shiva Laser Facility
Nova Laser Facility (in progress)
100 MeV Accelerator Facility
National Defense Support Livermore Computer Center
Gaseous and Metallurgical Facility (Plutonium & Tritium)
Magnetic Fusion Energy Facility (in progress)
14 MeV Rotating Target Neutron Source
Mirror Fusion Test Facility (MFTF-B) (in progress)
Tandem Mirror Experiment (TMX)
National Magnetic Fusion Energy Computation Center
Fusion Target Development Facility (in progress)
High Explosive Flash Radiograph Facility
Weapons Materials R&D Facility (in progress)

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[1] Current book value (including work in progress less accumulated depreciation).

[2] Percentages reflect Direct Full-Time Equivalent program effort (excluding Construction/Equipment).

[3] $5 million or more acquisition cost.

## LAWRENCE LIVERMORE NATIONAL LABORATORY (Continued)

**Major Active Facilities:**[3]

- Management Support Center—Core 1
- High Explosive Application Facility (in progress)
- Advanced Isotope Separation Facility (in progress)
- Advanced Test Accelerator Facility (in progress)
- Large Optics Diamond Turning Machine (in progress)
- High Explosive Processing and Test Facility

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$5 million or more acquisition cost.

## LOS ALAMOS NATIONAL LABORATORY
### Los Alamos, New Mexico

The Los Alamos National Laboratory's (LANL) primary mission is the application of science and technology to problems of national security, that is, to the maintenance of a strong defense, the fulfillment of arms control commitments, and the guarantee of a secure energy supply for the future. In carrying out this mission, the laboratory serves as a liaison between research in academia and industry and complements the activities of both. Major programs include developing nuclear warheads, designing and testing advanced technology concepts, and maintaining an innovative weapons design program. In nuclear fission, programs include separating isotopes of uranium by laser induction, testing advanced reactor fuel elements, modeling reactor accident results for the Nuclear Regulatory Commission, evaluating biomedical consequences of nuclear energy production, and developing effective nuclear waste disposal methods. In nuclear fusion, programs include magnetically confined plasma devices (especially high-beta devices), laser-induced fusion, and safe handling techniques for large quantities of tritium. Other programs include nonnuclear energy, basic energy science, and technology utilization.

| **Statistics:** | **FY 1982 (Estimated):** |
|---|---|
| DOE Operating Budget Costs: | $420 M |
| Staffing: | 6,770[1] |
| Capital Investment (Plant and Equipment): | $322 M[2] |
| Number of Acres: | 27,500 |

**Operating Contractor:** University of California

**Responsible Operations Office:** Albuquerque Operations Office

**Principal Program Activities:**

Weapons (48%)
Nuclear Physics (8%)
Magnetic Fusion (4%)
Advanced Isotope Separation
  Technology (4%)
Verification & Control (3%)
Breeder (3%)
Safeguards (2%)
Nuclear Materials Production (2%)
Miscellaneous DOE Programs (11%)
Other DOE (7%)
Work for Others (8%)
  Nuclear Regulatory Commission (2%)
  Department of Defense (3%)
  Other (3%)

**Major Active Facilities:**

800 Million Electron-Volt Linear Proton
  Accelerator (LAMPF)
Weapons Neutron Research Facility
Stable Isotopes Production Facility
20 Terrawatt $CO_2$ Gas Laser Facility
8 Megawatt Nuclear Reactor
Plutonium Research Facility
Plutonium Heat Sources Fuel Production Facility
National Security Resources and Studies Center

**Major User Facilities:**

Clinton P. Anderson Meson Physics
  Facility (LAMPF)
Central Computing Facility
Hot Dry Rock Project (Fenton Hill)

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[1] Figures are based on Full-Time Regular Employees.
[2] Current Book Value (excludes construction work in progress).

# OAK RIDGE NATIONAL LABORATORY
## Oak Ridge, Tennessee

The Oak Ridge National Laboratory (ORNL) primarily supports the fission nuclear fuel cycle and magnetic fusion energy development (advanced toriodal devices, such as Tokomak and Elmo Bumpy Torus) through scientific research and technology; identifies and solves generic research problems in energy technologies such as materials, separation techniques, chemical processes and biotechnology; and is the major national source of production of stable and radioactive isotopes. Energy technology development at ORNL also includes other important efforts in residential and commercial energy conservation, renewable energy sources, and coal conversion and utilization. ORNL expends special effort to involve industry in its programs and to encourage cooperative uses of facilities, both formally in users' groups and informally through professional contacts and participation. Similarly, the Laboratory provides universities with ready access to major research facilities, state-of-the-art research capabilities, training facilities for faculty and students, and an opportunity for collaborative research in areas where these sources are not available to universities.

| **Statistics:** | **FY 1982 (Estimated):** |
|---|---|
| DOE Operating Budget Costs: | $278 M[1] |
| Staffing (Full-Time Equivalent): | 4,950 |
| Capital Investment (Plant and Equipment): | $250 M[2] |
| Number of Acres: | 10,270 |

**Operating Contractor:** Union Carbide Corporation, Nuclear Division

**Responsible Operations Office:** Oak Ridge Operations Office

**Principal Program Activities:**[3]

- Fission Energy Development (24%)
- Basic Physical Science (21%)
- Biomedical and Environmental Sciences (12%)
- Fusion Energy (9%)
- Conservation and Renewable Energy (5%)
- Fossil Energy (4%)
- Miscellaneous DOE Programs (6%)
- Work for Others (19%)
  - Nuclear Regulatory Commission (8%)
  - Department of Defense (1%)
  - Others (10%)

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[1] Costs based on the FY-82 column of Oak Ridge Operations Office's FY-83 budget.

[2] Current book value of plant and equipment including construction work in progress as of September 30, 1981.

[3] Percentages reflect direct staff Full-Time Equivalents.

## OAK RIDGE NATIONAL LABORATORY (Continued)

**Major Active Facilities:**

Isotopes Separation Facility
High Flux Isotope Reactor
Electron Linear Accelerator
Transuranium Processing Plant
Oak Ridge Research Reactor
Oak Ridge Isochronous Cyclotron
High Level Radiochemical Laboratory
Materials Processing Laboratory
Thorium Uranium Fuel Recycle Facility
High Radiation Level Examination Laboratory
Enviromental Sciences Laboratory

**Major User Facilities:**

Holified Heavy Ion Research Facility
EN-Tandem Accelerator
Oak Ridge Electron Linear Accelerator (ORELA)
Neutron Scattering Facility
National Center for Small-Angle Scattering Research
Ion-Solid Interactions Laboratory
Shared Research Equipment Program (SHARE)

## PACIFIC NORTHWEST LABORATORY
### Richland, Washington

The mission of the Pacific Northwest Laboratory (PNL) is the advancement and use of multi-energy scientific and engineering technology for national security and the nation's energy needs. In accomplishing this mission, high priority is given to safe and reliable nuclear energy, and to promising new concepts and technologies for operations at Hanford. Areas of disciplinary strengths and concentration include nuclear waste process development, nuclear fuel development and evaluation, spent fuel storage reprocessing, inhalation toxicology, bioelectromagnetics, biology, ecology, atmospheric sciences, corrosion chemistry, biomass research, nondestructive testing and evaluation, materials characterization and research, chemical engineering, health physics technology, and energy economics and policy analyses. The laboratory provides a core capability for effectively utilizing the strengths of the universities and the private sector and has traditionally developed and maintained strong ties with the academic community. That resource is utilized through cooperative exploratory research efforts to accelerate application of new ideas, scientific research support to PNL efforts on team assignments, and exchange of staff and student research. Industry and utilities participate with PNL staff in efforts to develop advanced technology, to improve existing instruments or develop new ones, and to investigate and demonstrate energy conservation and conversion techniques.

| **Statistics:** | **FY 1982 (Estimated):** |
|---|---|
| DOE Operating Budget Costs: | $98 M |
| Staffing (Full-Time Equivalent): | 1,975 |
| Capital Investment (Plant and Equipment): | $65 M |
| Number of Acres: | Not Applicable[1] |

**Operating Contractor:** Battelle Memorial Institute

**Responsible Operations Office:** Richland Operations Office

**Principal Program Activities (FY 1982 Estimated):**

Fission (25%)
Defense (17%)
Life Sciences (16%)
Conservation (7%)
Renewable (7%)
Basic Sciences (5%)
Miscellaneous DOE Programs (3%)

Work for Others (20%)
  Nuclear Regulatory Commission (15%)
  Department of Defense (3%)
  Others (2%)
Biomass Experimental Unit
Geophysical and Astronomical Observatory
National Enviromental Research Park

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[1] PNL facilities are in an area shared with Hanford Engineering Development Laboratory and UNC Nuclear Industries.

## PACIFIC NORTHWEST LABORATORY (Continued)

**Major Active Facilities:**

- Two Life Science Laboratories
- Marine Research Laboratory
- Meteorological Center
- Critical Mass Laboratory
- Nuclear Waste Vitrification Laboratory
- Materials Reliability Center
- Steam Generator Examination Facility

**Major User Facilities:**

- Critical Mass Laboratory

## SANDIA LABORATORIES
### Albuquerque, New Mexico; Livermore, California; Tonopah, Nevada

Sandia Laboratories' principal mission has been and remains research, development, and engineering of nuclear weapon systems, except for the nuclear explosive. The result of this effort is the existence of a national stockpile of nuclear weapons that are safe, secure, reliable, under strict control, and operationally ready. Sandia is also responsible for major energy programs in fossil, solar, fission, and basic energy sciences. Its strength lies in its ability to conduct large, interdisciplinary engineering projects that are both technologically "risky" and sophisticated. Fundamental understanding and technological development are melded to create an environment conducive to generating new products and processes that are unlikely to be produced in either university or industrial laboratories. These new technologies are transmitted to the private sector through journals, workshops, and other information transfer mechanisms, and significantly contribute to the nation's scientific and economic prosperity.

| **Statistics:** | **FY 1982 (Estimated):** |
|---|---|
| DOE Operating Budget Costs: | $610 M |
| Staffing (Full-Time Equivalent): | 7,950 |
| Capital Investment (Plant and Equipment): | 208 M[1] |
| Number of Acres: | 3,140 (Albuquerque)<br>185 (Livermore) |

**Operating Contractor:** Western Electric Company

**Responsible Operations Office:** Albuquerque Operations Office

**Principal Program Activities:**[2]

Defense Programs (67%)
Conservation and Renewable Energy (6%)
Nuclear Energy (5%)
Fossil Energy (3%)
Energy Research (3%)
Environmental Protection, Safety, and Emergency Preparedness (1%)
Work for Others (15%)
  Department of Defense (8%)
  Nuclear Regulatory Commission (5%)
  Others (2%)

**Major Active Facilities:**[3]

Particle Beam Fusion Facility
Nuclear Safeguards and Security Facility
Combustion Research Facility
5-megawatt Solar Central Power Test Facility
Center for Radiation-hardened Microelectronics
Tonopah Test Range
Radiation/Simulation Facilities

**Major User Facilities:**

Combustion Research Facility
Solar Central Power Test Facility
Tonopah Test Range
Radiation/Simulation Facilities

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[1] Current Book Value (Excludes Construction Work in Progress)
[2] Percentages reflect direct staff (full-time equivalent).
[3] Major construction line items only.

# ATTACHMENT C

## Significant Accomplishments Illustrative of Multiprogram National Laboratory Research

## AMES LABORATORY

- The Ames Laboratory developed efficient reduction and purification processes for uranium, thorium, the rare earths, zirconium, hafnium, yttrium, and vanadium. All of the processes have been adopted by industry, and all are in use today. Essentially all of the uranium used in the Western world has been prepared by the Ames process, and the entire rare earth industry is largely dependent upon the basic separations and chemical, metallurgical, and materials characterization achievements of this Laboratory (1940 to present).
- The development of the inductively coupled plasma atomic-emission spectroscopy method for multi-element analysis was carried out at the Laboratory. The method is very fast, requires minute amounts of sample, and permits simultaneous identification of up to 50 elements; for most of these elements, this method is more sensitive than any other. Commercial instruments based on this development have been introduced: six U.S. and 11 foreign companies are now marketing such instruments at a sales rate of about $100 million per year (1970s).
- Development of a ductile, composite superconducting wire suitable for large-scale magnets in the 12- to 14-tesla range was carried out by an interdisciplinary team of metallurgists and solid state physicists at Ames Laboratory. The material is easy to fabricate and has the high strength and strain tolerance needed for toroidal field magnets in Tokamak fusion reactors (1970s to present).
- The Ames Laboratory developed the basic science for sampling, isolating, and quantitating the trace organic compounds in water. The isolation techniques have increased detection power approximately 10,000-fold for most compounds of environmental interest. The methodology has been adopted nationally and internationally by government, university, and industrial laboratories (mid to late 1970s).
- Recently a reactive radio frequency sputtering method for the preparation of hydrogenated amorphous silicon films for solar cells was developed here. The method permits the preparation of large-area films needed for solar panels while retaining the careful control of the local environment of the hydrogen ions, which is needed for high performance (1978 to present).
- Very recently a method based on high-resolution solid state nuclear magnetic resonance in coal samples has been developed for determining the sizes of the polynuclear aromatic rings in the molecular structure of coal. These results, compared with similar results on liquid fuels produced from coal, are used to study the effects of the chemical processing steps in liquefaction (1978-1980).
- The Laboratory has also recently completed the development of a laser/mass spectrometer probe capable of detecting 62 elements present in concentrations as low as 1 ppb in phases of solids whose dimensions are as small as 10 to 20 μm and it is applicable to metals, semiconductors, and insulators. Accurate analyses can be made without the use of standards (mid-1970s to present).
- Chemical engineers and materials chemists at the Ames Laboratory have developed methods for improved control of the complex chemical equilibrium governing the separation of plutonium from uranium in fuel processing. The programs developed in the work are now being used in nuclear safety and nuclear safeguards programs in the United States (1973-1976).
- The development of a liquid junction solar cell using $WSe_2$ and $MoSe_2$ with efficiences of 10% and 9.5% and no detectable photocorrosion of the electrodes after extended illumination was recently carried out by an interdisciplinary group from the Materials Chemistry and Solid State Physics divisions at Ames (1977-1980).
- Ames Laboratory scientists are responsible for the recent development of a provisional international practical temperature scale for use by the entire scientific community. A large portion of fundamental research between 0.5 and 35 K was done by the Laboratory, and the scale was adopted by the International Commission on Weights and Measures (CIPM) (1975-1976).

## ARGONNE NATIONAL LABORATORY

- Water-cooled nuclear reactor research, design, and development at Argonne National Laboratory contributed significantly to the establishment of the nuclear power industry and in the nuclear-powered submarine. The Laboratory still provides reactor and reactor waste safety information (1946 to present). This capability was applied to the following projects:
    1. design of the first land-based prototype submarine reactor,
    2. design of the first reactor using heavy water as a moderator and coolant,
    3. basic design of the Savannah River production reactors, and
    4. development of the boiling water reactor concept [Boiling Reactor Experiments (BORAX), Experimental Boiling Water Reactor (EBWR)].
- Liquid-metal Cooled Fast Breeder Reactor (LMFBR) research, design, and development at Argonne provided the technology foundation for these reactors and continues to provide component and materials testing and evaluation. It has accumulated 16 years of LMFBR operational experience in the production of electricity. This research produced the following advances:
    1. design of the first successful breeder reactor (EBR-I), which produced the first usable amounts of nuclear-generated electricity;
    2. development of fast reactor and high-temperature reactor fuel materials; and
    3. development of the world's first transient reactor test facility (TREAT) to study fuel behavior during sudden power surges (1946 to present).
- A prototype superconducting linear heavy-ion accelerator is operational. When a total of seven modules are completed, the Argone Tandem-Linac Accelerator System (ATLAS) will be able to provide 1.5 GeV particles, previously unavailable, that will improve understanding of nuclear binding forces (1979 to present).
- Intense Pulsed Neutron Source-I (IPNS-I) provides the world's most powerful source of non-reactor neutrons, which will be used to study radiation effects in fission and fusion reactor materials. Other applications will include areas of physics, chemistry, and biology (1971 to present).
- Zero Gradient Synchrotron (ZGS) acceleration of polarized protons was used to study spin-spin interaction between protons at high energy. Contrary to the existing belief, spin effects were shown to be large (1971-1979).
- Liposome encapsulation, the technique of coating minute amounts of a drug with naturally occurring fatty substances called phospholipids, was developed at Argonne. The microscopic capsules formed by this technique penetrate individual cells, where the fatty coating is dissolved by enzymes and the drug is allowed to do its work without having been weakened or diluted by the body's defense systems. When applied to cancer chemotherapy,liposome encapsulation allows the destruction of diseased cells from within, while leaving nearby cells unharmed. Eleven companies are currently using the technique to improve the efficiency of their anti-cancer agents (1973 to present).
- ISO-DALT, a two-dimensional electrophoretic system that separates and maps human serum proteins together with TYCHO image analysis and the KEPLER data base, will become a powerful diagnostic tool for extremely early detection of many diseases in man and will be applicable to large populations (1978 to present).
- Mathematical software has been designed and developed, including EISPACK for eigenanalysis, FUNPACK for approximations of special functions, LINPACK for solution of linear systems, MINPACK for numerical optimization, and SPEAKEASY for matrix manipulations. There is also AURA, which functions as an "automated reasoning assistant" and interacts with the scientist to solve problems. Distribution on EISPACK alone includes over 1000 research centers in over 70 countries (1972 to present).
- The world's largest high-field superconducting magnets, used in magnetohydrodynamics generators of electricity and in high-energy-physics bubble chamber experiments, have been designed and developed (1963 to present).
- Fluidized-bed combustion is a technology that has been developed to permit the use of high sulfur coal. Ninety percent of the sulfur combines with limestone during combustion, thereby reducing air pollution. Attention is now focused on recycling the limestone (1963 to present).

## BROOKHAVEN NATIONAL LABORATORY

- The large particle accelerators that Brookhaven National Laboratory (BNL) has designed, built, and operated as national facilities have been the sources of many discoveries in particle physics which have led to a deeper understanding about the nature of matter. The first observation of a charmed baryon was made at BNL; and two recent Nobel prizes in physics, 1976 and 1980, were awarded for work carried out at BNL: the discovery of the J/psi particle in 1974 and the experiment which showed the violation of a fundamental symmetry principle in 1963.
- The magnetic principle of alternating gradient strong focusing discovered at BNL has been, and continues to be, the critical advance upon which construction of synchrotrons capable of accelerating protons to 100's of GeV depends. This fundamental discovery had two important consequences: it greatly reduced the cost of accelerators by allowing much smaller aperatures, and it provided a means of transporting extracted or secondary beams (produced by interactions of the primary beam with a target) to experimental apparatus located far from the accelerator. Both of these applications are essential to all modern proton synchrotrons, which now operate at energies as high as 500 GeV (1952 to present).
- Research reactors developed at BNL have consistently been at the forefront of design of these very important research devices. The Brookhaven graphite research reactor in 1950 became the first peace-time research reactor; it supported most of the free world's neutron beam research until 1966, when the Brookhaven High Flux Beam Reactor (HFBR) came on line. The HFBR is now the nation's most sophisticated and most heavily used reactor for neutron beam research. Recent improvements include increasing the power by 50% and installing a cold neutron source (i.e., a source of very-low-energy neutrons used in solid-state physics research); these improvements assure continued preeminence in the research reactor field.
- Neutron cross section experiments and criticality experiments on the properties of lattices of uranium rods in water conducted at BNL provided the basis for the design of light water reactors that now produce most of the world's nuclear-generated electricity. In addition, the compilation, evaluation, and storage of data from the neutron cross section experiments and, more recently, from other nuclear experiments have led to the creation of a central repository for most of the nuclear physics data generated throughout the world (1950s to present).
- Neutron scattering experiments at BNL's High Flux Beam Reactor have definitely established the nature of the magnetic state and its competition with superconductivity. This crucial step in relating these two very fundamental and technologically important properties of materials will eventually lead to deeper understanding and more sophisticated applications of these properties (1976 to present).
- By the middle of the 1970s, sufficient data were obtained from a 600-ton solar neutrino detector situated 1 mile underground to show that either our current views of the details of the nuclear reactions generating the sun's energy are incorrect or that our understanding of the fundamental properties of neutrinos is not complete. Since both of these possibilities are of great interest, a new experiment designed to eliminate one of them is underway.
- The first demonstrated transformation of human cells in culture by ultra-violet light was shown at BNL; this discovery now opens the way for laboratory studies of cancer-producing mechanisms (1980 to present).
- The first correlation between the ability to repair damage to DNA and the life span of different mammalian species was discovered by a BNL scientist who is now investigating the relationship of DNA repair to aging in humans (1974 to present).
- The invention at BNL of a procedure by which the short-lived radiopharmaceutical $^{99m}$Te could be effectively distributed and used by the medical community started a new generation of nuclear medicine applications. This isotope continues to account for approximately 80% of the one mission administrations of radiopharmaceuticals per year in the U.S. and is the basis of a $100 million commercial enterprise, domestically.

## BROOKHAVEN NATIONAL LABORATORY (Continued)

- The labeling of 2-fluro-2-deoxy-d-glucose with radioactive $^{18}F$ at BNL and use of this radiopharmaceutical in conjunction with positron-emission transaxial tomography (PETT) has initiated widespread activity in many new areas of medical research; measurement of regional metabolic activity at accurately determined locations inside the brain is now possible. The technique has led to a much detailed understanding of a whole range of phenomena (e.g., drug response) and diseases (e.g., senility, stroke, and schizophrenia) that affect the brain. The National Institutes of Health (NIH) are now supporting about ten centers to carry out this type of work (1976 to present).

## LAWRENCE BERKELEY LABORATORY

- The Lawrence Berkeley Laboratory (LBL) has been responsible for numerous major advances including the invention of the cyclotron, the linear accelerator, the synchrotron, and continuing contributions to new particle accelerator concepts and construction projects (1929 to present).
- The creation and identification of 15 new chemical elements, including plutonium, by nuclear synthesis was carried out by scientists at LBL (1940-1976).
- Particle research conducted by scientists at the Laboratory led to the discovery of the antiproton and numerous excited states of the fundamental particles (1955-1965).
- The Laboratory became one of the world's major centers of heavy-ion nuclear physics research by (1) adapting the 88-Inch Cyclotron to the acceleration of heavy ions (1971); (2) connecting the SuperHILAC heavy-ion accelerator to the Bevatron to make the Bevalac (1972); and (3) improving the Bevalac (1981) to provide acceleration of ions as heavy as uranium to multi-billion-volt energies, a capability unavailable anywhere else in the world. SuperHILAC, Bevalac, and 88-Inch Cyclotron accelerators serve as national facilities for nuclear physics and biomedical research (1971 to present).
- The LBL was responsible for the founding of the National Center for Electron Microscopy equipped with instruments of highest energy and highest resolution (1980 to present).
- The Laboratory was also responsible for the founding of the science of nuclear medicine (1935), the continued development of instruments and techniques for the beneficial use of gamma and particle radiations (1935 to present), and the exploration of use of heavy ions for treatment of cancer.
- The Laboratory has contributed significantly to discoveries and developments in high energy physics: for example, discovery of the Ψ family of particles, the discovery of charmed particles, the design and construction (with Stanford Linear Accelerator Center) of the Positron-Electron Project accelerator, the design and construction of the Mark I and II massive detector systems, the design of the Time Projection Chamber superconducting magnet, and the development of stochastic beam cooling (1974 to present).
- The Laboratory has also done research and development on particle injection into fusion reactors for heating and fueling and design and construction of neutral beam injectors for Lawrence Livermore National Laboratory's 2X-IIB, Princeton's Tokomak, and General Atomic's Doublet III (1974-1981).
- The large-scale field experiment was conducted in an iron mine in Stripa,Sweden, to measure rock characteristics significant to underground storage of nuclear wastes (1976).
- The LBL has been responsible for the development of instruments now used in hundreds of university and corporate laboratories for precise measurement of gamma radiation, x-rays, nuclear particles, chemical elements, chemical compounds, magnetic field strengths, and other properties (1950-present).

## LAWRENCE LIVERMORE NATIONAL LABORATORY

**Weapons**

- Since its establishment in 1952, LLNL, in conjunction with Los Alamos and Sandia, has continued to function as an integral scientific and technical element of the nation's nuclear weapons program including all facets of nuclear weapon technology and the supporting scientific and engineering disciplines. Particularly, significant achievements have been made in such areas as reduction in size and weight, and enhanced safety, flexibility, and military effectiveness of nuclear weapons. These advances in design have enabled the defense community to provide the nation with increasingly effective warhead capabilities for its nuclear weapons systems.

**Nonweapons**

- Under inertial confinement fusion, LLNL developed the technology for 100 TW Nd: glass laser systems. This technology, now adopted as the international workhorse for ICF research, was successfully transferred to U.S. industry in 1975. In addition, LLNL developed the first ultrafast (~20 psec) x-ray streak camera (now becoming commercialized) and the first use of micro-fabrication technology for high resolution imaging of alpha particles and x-rays (1976-1978). In integrated fusion experiments, the Laboratory provided the first confirmation of laser induced thermonuclear reactions (1975), the first demonstration of energy scalable ablative implosions (1976), and achieved a systematic scaling of imploded fuel density, up to 100 times liquid density, on the Shiva laser facility (1978-1979). Also definitive improvements in target performance at visible and ultraviolet wavelengths were demonstrated on the Argus laser facility. For fusion energy applications, LLNL researchers conceived and assessed the excimer laser driver and the HYLIFE reaction chamber, which features a long-lived (30 year) liquid lithium "first wall" (1977-1981).
- Within the Atomic Vapor Laser Isotope Separation (AVLIS) Program, researchers separated uranium isotopes (1974); demonstrated macroscopic uranium enrichment utilizing critical subsystems scalable to production plant size (1978); developed a high-power tunable (isotopically selective) laser system which is economically competitive (1981); and activated a full-scale uranium vaporizer unit (1981).
- Livermore's involvement in magnetic fusion research dates from the founding of the laboratory in 1952. As lead laboratory for the National Magnetic Mirror Program, LLNL achieved thermonuclear plasma temperature with near-classical confinement in the 2X-IIB experiment (1978); demonstrated the adaptation of the mirror concept of an efficient reactor design in TMX (1980); and developed, with LBL large neutral high-field superconducting magnets Baseball II and Mirror Fusion Test Facility, MFTF (1981), which enhance related energy technologies like magnetohydrodynamics.
- Livermore has pioneered in underground engineering and experiments for weapons applications. Transfer to nonweapons applications includes rock fracturing for fossil energy applications and incorporating high-level radiation wastes in crystal lattices of synthetic rocks that are related to natural minerals with extremely long-period stability. In-situ coal gasification was demonstrated in experiments at Hoe Creek, Wyoming (1979), that produced a medium BTU gas suitable for chemical synthesis or upgrading to pipeline quality. Industry has contributed resources to this effort.
- Beginning in 1972 and building on the foundation laid by LANL, LLNL has been a world-wide leader in the development of analytical cytology (flow cytometry, flow sorting, computer-based scanning microscopy, cytochemistry) and its application to energy-related toxicology. The laboratory has founded the new field of flow cytogenetics in which chromosomes are analyzed at high speed and resolution, and can, for the first time, be purified by type. LLNL researchers are also pioneering the application of analytical cytology to rare event detection, most noteworthy of which is the detection of somatic mutant cells in human blood. A practical assay for human somatic mutation would be a major breakthrough in the interface between preventive medicine and modern technological development.
- The Laboratory was also responsible for the development of the Atmospheric Release Advisory Capability (ARAC) System for predicting the exposure consequences from accidental releases of radioactivity with real-time communications to system sites. Conceptual studies were done in 1972; limited implementation occurred between 1974 and 1976; and the system was applied to the Three Mile

## LAWRENCE LIVERMORE NATIONAL LABORATORY (Continued)

Island (TMI) accident and Kemeny Commission studies in 1979 and to the TMI Purge in 1980.

- Precision engineering and machining techniques for the design, fabrication, and inspection of highly precise mechanical workpieces have been under continual study and development since 1955. Two diamond turning machines were constructed (1968-72) for unprecedented accuracy in the machining of parts, and a third is in development. Assistance has been provided in transferring this technology to industry.
- A systems study of the aluminum-air power cell and its use in automotive propulsion, including performance, cost, and energy efficiency estimates was completed (1980). With industrial participation, the Laboratory is now developing and evaluating a prototype metal-air power cell as an automotive energy source with the range, acceleration, and rapid refueling capability of current internal-combustion engines.

## LOS ALAMOS NATIONAL LABORATORY

### Weapons

- Established in 1943, Los Alamos National Laboratory (LANL) developed the first fission and thermo-nuclear weapons. In conjunction with Sandia and LLNL, LANL has continued to maintain U.S. superiority in all facets of nuclear weapons technology and supporting scientific and engineering disciplines. Enhanced safety, flexibility, and military effectiveness have been produced through a reduction in size and weight of the weapons. These advances in design have enabled LANL to provide increasingly effective warhead capabilities for integration into a number of defense systems serving every branch of service.

### Nonweapons

- Examples of major Los Alamos accomplishments before 1970 include designing, building, and operating the world's first plutonium-fueled fast reactor and the world's highest temperature and power density fission reactors, thereby establishing possibilities for advanced fission systems and eventual process heat applications. Los Alamos also achieved the first laboratory demonstration of controlled thermo-nuclear fusion, thereby establishing the possibility of eventual electricity production from fusion reactions.

- The Molecular Laser Isotope Separation (MLIS) Process for the enrichment of uranium has been developed to the point of demonstrating process feasibility. If developed to production scale, the MLIS process would result in a significant reduction in energy consumption and cost compared to diffusion and centrifuge technology. In response to the needs of the MLIS Program, state-of-the-art advances have been made in the area of laser research and development. The high-power, electric discharge excimer laser operating on all rare gas-halogen combinations has been successfully developed primarily at Los Alamos and by the Laboratory's direct contractors. In addition, LANL has pioneered the development of pulsed isotopic carbon dioxide lasers having long operating lifetimes and a high degree of stability. LANL contractors have produced the first high repetition rate, stable isotopic carbon dioxide lasers at the kilowatt/kilohertz level.

- Fast-reactor fuels of plutonium carbide developed by Los Alamos successfully attained specific power production ("burnup") of over 150,000 mwd/ton(1981). This is much higher than that offered by present oxide fuels now used in breeder reactors. The new fuel has also demonstrated the capability of undergoing severe heating transients without performance degradation, an important safety feature. The combination of the improved thermal, mechanical, and neutronic performance of carbide fuel could lead to significant savings in fast-reactor fuel fabrication costs and in overall plant and operating costs as well.

- Special plutonium fuels using a Los Alamos oxide of $^{238}$Pu and $^{16}$O now provide long-life, stable, low background heat sources which generate electricity for experiments on the moon and on the Voyager spacecraft. Newly developed general purpose heat sources employing the same material will be combined in modular arrangements to power the Galileo Deep Space Probe and the Polar Orbiter solar studies mission. The same material, used in smaller radioactive heating units, has numerous space and terrestrial applications.

- Reactor transient codes designed by Los Alamos have been used to understand the behavior of complete nuclear reactor systems under accident conditions. These computational methods were successfully applied shortly after the Three Mile Island accident to reproduce that plant's behavior during the accident. Developments now under way suggest that this computational skill can be incorporated into high-speed microprocessor units at the power plants. This would give their operators rapid analysis during the course of a potential accident, guiding their response more surely to prevent the accident or reduce its consequences.

- The idea of extracting geothermal energy from structurally sound subterranean "hot dry rock" found nearly everywhere was conceived at Los Alamos eight years ago and has already had a first demonstration of technical feasibility. Heat transfer surfaces were created by fracturing the hot rock between deep drill holes and connecting the holes above ground to form the world's first closed loop geothermal energy system. This environmentally-clean recirculating system produced an average 2.6 megawatts (MW) of power for over 10,000 hours, and a portion of this was regularly used to generate onsite electricity up to 60 kilowatts (kw). Now, under joint sponsorship of the USDOE and the governments of West Ger-

## LOS ALAMOS NATIONAL LABORATORY (Continued)

many and Japan, a larger (35 MW) engineering system is being constructed (in 300°C rock at 4050 m depth) to demonstrate commercial feasibility. The project has already advanced that state-of-the-art in hard rock drilling has pioneered in deep drilling (two-three miles) at high temperatures. Many of the new high-temperature downhole tools and instruments developed for this work have already been adopted by industry. Prospecting techniques developed at the Laboratory are now being used to define and map the more readily accessible parts of this enormous nationwide resource.

- Flow cytometry, developed at Los Alamos, is automatic high-speed sorting of thousands of specific cells, chromosomes, etc., per second using laser illumination of individual cells to measure and select cell size, structure, and chemical composition (1972). This newly transferred technology is already worth several million dollars annually to industry. It is used in health research laboratories and is entering medical and clinical use. It is being applied to disease diagnosis and identification of genetic diseases and tumor cells; it is also being used to study the effects of radiation therapy, drugs, or toxic agents on cells and to develop chemotherapeutic cancer treatment schedules. An emerging application may make it possible to quantify the importance of chromosome aberrations as biological markers for chemical exposure (1972).
- Nonconventional hard materials are a very recent development that may replace tungsten carbide-cobalt in armor-piercing munitions, machine tool bits, mining drilll bits, and other applications where high hardness and abrasion resistance are important. These materials do not require strategic materials or cobalt and will use less tungsten. This development has both commercial and defense applications (1981).
- Accelerator developments at Los Alamos have found many practical applications. The mid-1960s discovery of the side-coupled cavity concept greatly increased the efficiency of transferring power to linear accelerator beams and is now adopted almost universally. Recently, LANL has learned how to apply the RF quadrupole bunching and guidance concept successfully to the low-velocity portions of ion linear accelerators. Essentially all such new machines are expected to adopt this technology as well. At the Los Alamos Meson Physics Facility (LAMPF), an accelerator which is nationally and internationally used, researchers have pioneered in the treatment of deep-seated human tumors by pion radiotherapy. Clinical successes and availability of the above technological improvements have encouraged the development of a compact machine especially optimized for hospital use. it is called PIGMI (Pion Generator for Medical Irradiations), and its design concepts are being shared with domestic companies and companies in Japan and Sweden.
- A program for the separation of isotopes of carbon, nitrogen, and oxygen (ICON/L/C) has produced kilogram-per-year quantities of $^{13}C$, $^{15}N$, $^{17}O$, and $^{18}O$. The unique 225-m long, cryogenic distillation column of this program is the major source of these isotopes in the Western world. The separated stable isotopes are utilized in physical and biomedical sciences and in environmental studies through basic research programs and extensive cooperative ventures with universities and medical schools.

## OAK RIDGE NATIONAL LABORATORY

- Oak Ridge National Laboratory (ORNL) served for over 30 years as the principal developer and reference source for models and techniques to estimate radiation doses received by humans. Essentially all nations have uniformly adopted usage of the ORNL models and techniques through the recommendation of the International Commission on Radiological Protection (1940s to present).

- The Laboratory has developed advanced centrifuge techniques producing pure vaccines and for performing rapid medical diagnoses. These are now in wide-scale commercial use (1965-1975).

- The development of radionuclide production for nuclear medicine applications was initiated at ORNL, and, in conjunction with medical schools and hospitals, the Laboratory developed efficient radiopharmaceuticals as imaging agents to study heart disease and locate brain tumors (1945 to present).

- The first heavy-ion cyclotron was constructed at ORNL, and the field of heavy-ion physics was founded by establishing the general properties of heavy-ion elastic scattering, transfer reactions, and compound nuclear reactions (1950 to present).

- Crucial determinations were made of neutron radiation damage, including radiation-induced creep, in metals and alloys; contributions in this area have been necessary for the development of nuclear reactors (1949 to present).

- Theory and supporting data for the design of heavy section steel vessels were developed at ORNL. The results of this program have provided an assurance of safety necessary for the light-water reactor (LWR) pressure vessel, which has been accepted by regulatory bodies both in the United States and other countries (mid-1960s to present).

- The Laboratory provided rapid and extensive assistance during the Three Mile Island incident, from the beginning until now. Radiochemical, chemical, and isotopic measurements were made, along with a variety of physical tests. ORNL developed the process flowsheet for the cleanup of the water from the containment building. ORNL also resolved the question of why iodine releases were so low and showed that much lower iodine releases than previously predicted would occur in many LWR accident scenarios (1980 to present).

- For nuclear fuel reprocessing, ORNL developed Purex (1953), Thorex (1958),and Remotex (1980). Purex and Thorex processes are now used in all known fuel reprocessing plants throughout the world. Remotex is a fully remote processing concept which has been used for most radioisotope systems and also has been applied to the handling of hazardous materials such as carcinogenic compounds.

- The major contributions to the development and application of neutral injection heating for fusion were made at ORNL. These include the development of the initial physics and technology, as well as a prime contribution to the initial applications and understanding of this important plasma heating technique (1969 to present). Devices were also developed at ORNL which, in conjunction with the Princeton Plasma Physics Laboratory, produced a 70 million degree plasma in the Princeton Large Torus (1978).

- A broad array of instrumentation and monitoring techniques for fossil-energy-related applications was developed that provides the basis for work area monitoring for industrial hygiene purposes of a broad class of carcinogenic polyaromatic hydrocarbons (PAH) which are produced in coal conversion reactions. The instruments include the derivative ultraviolet absorption spectrometer (DUVAS) for detection of specific gaseous organic emissions, the portable "spill spotter" for detection and quantification of work surface PAH contamination, the light-pipe lumminoscope for detection of PAHs on skin, and a personnel monitor for determining individual worker exposure to volatile organics, including PAHs (1977 to present).

## PACIFIC NORTHWEST LABORATORY

- The Pacific Northwest Laboratory (PNL) successfully demonstrated the immobilization of high-level waste from the nuclear fuel reprocessing of six commerical fuel assemblies in a stable glass form for storage (1976-1979). The process is being transferred to the Savannah River Laboratory for use in the Defense Waste Processing Facility. It will be used in the West Valley Demonstration Project to solidify the liquid high-level wastes stored in tanks at the site.
- For over 30 years the Laboratory has conducted experimental research that has lead to major improvements in nuclear power plant and core fuel performance, core life, plant safety, and plant factors. This research has included a cooperative program (1973-1975) with Japan and several European countries that led to resolution of fuel densification questions threatening shutdown of numerous nuclear power plants in the United States and throughout the world.
- The Laboratory established the technical, health, and environmental basis for the private-sector use of mixed oxide (plutonium and uranium) fuels in light water reactors (1960-1970). The studies have led to a technology base for a better understanding of the use of uranium oxide and mixed oxide fuels. The technology was adopted by one corporation as a new venture of providing mixed oxide and uranium oxide fuels that has grown to a multihundred million dollar fuel reload business with a billion dollar backlog (1967-1975). Also, critical mass data for plutonium, uranium, and mixtures of the two provided information used by industry to design nuclear fuel cycle facilities and equipment (1967 to present).
- Electropolishing and vibratory-finishing techniques for decontaminating metal surfaces were developed at PNL. These techniques are being used for the cleanup at Three Mile Island; they have been incorporated in mobile decontamination units operated by seven commercial companies; and they are factored into decontamination plans of most DOE sites (1975-1980).
- An advanced cooling-tower process that used little or no water was developed; this is an important alternative for arid Western states and other regions of uncertain future water supply. The concept is being demonstrated by the private sector at a utility power station and holds the potential of 30% to 40% cost reductions over existing dry-cooling technology (1974-1981).
- High-rate and large-volume sputtering processes have been developed for the versatile fabrication of special-purpose materials and coatings. The technique has been used for coating turbine blades for increased reliability, fabricating materials for high-energy-laser mirrors, and trapping krypton gas in metals in order to meet release criteria for nuclear reactors and other nuclear facilities (1969 to present).
- Experiments on effluents and products for coal conversion processes conducted for about six years suggest that mutagenic and probably carcinogenic effects of coal liquids are due to a relatively small faction of the constitutents of coal conversion liquids. Mutagenic effects are due to primary aromatic amines. Also, researchers found that coal liquids, because of their high phenol content, are more toxic to aquatic organisms than petroleum and petroleum-based fuels. Hydrotreatment of the coal liquefaction materials reduces these toxic constituents and is expected to ameliorate effects. Results are being used by industry to (1) develop alternative coal conversion processes that produce less phenol and fewer primary aromatic amines, (2) modify processes to remove these mutagenic and toxic constituents, and (3) assess potential environmental and health impacts of a commerical coal liquefaction industry (1976-1981).
- The Laboratory has developed a cationic asphalt emulsion that can be used to seal radon gas in piles of uranium tailings. The new emulsion forms a tight electrostatic bond with the soil rather than the usual mechanical bond. Results after six months of a field study with the new emulsion indicate a greater than 99.99% reduction in the amount of radon gas normally released from uncovered tailings (1978-1981).
- Health and environmental studies of radionuclides have been conducted at Hanford for over 30 years using Hanford-developed instruments and procedures for low concentration measurements. Health effects of transuranic (radioactive) elements were measured as a function body entry route, specific radiation compound, and animal species and ages. Possible synergistic and antagonistic effects of combined exposures to transuranic elements and

## PACIFIC NORTHWEST LABORATORY (Continued)

nonnuclear environmental contaminants were determined. Effects of environmental exposure routes and mechanisms of biological availability of transuranic elements were also ascertained. These data are widely used in setting or justifying existing radiation exposure standards and as a basis for resolving issues and making decisions. For example, results from studies of plutonium have clarified questions about potential health effects of plutonium and the issue of "hot particles"; and results from krypton inhalation studies supported that decision to vent krypton gas at Three Mile Island (1977-1981). The extreme measurement sensitivities resulting from the instrumentation developments and radioanalytical procedures have been used for meteorite and lunar sample analysis, exploitation of mineral resources, nuclear proliferation control, and categorization and characterization of pollutants from all phases of energy production.

- The Laboratory has been instrumental in developing siting and methodology criteria in support of major national programs. In the 1960s, extensive environmental studies were conducted at both Cape Canaveral, Florida, and Vandenberg Air Force Base, California, which established criteria for safety in expanding space programs, including that required for siting of launch facilities. In the early 1970s, the response to new legal requirements for environmental assessment of commercial nuclear facilities, measurement and analysis methods were established to determine the health and environmental impact from nuclear operations. Criteria and procedures developed by PNL for environmental impact statements of nuclear reactors were rapidly deployed and are still used by industry. More recently (1977-1981), siting criteria, realistic wind data, and measurement techniques have been developed that facilitate the use of modern large and small wind turbines in the continental United States. Specific uses of the PNL information and techniques by the private sector include: (1) screening potential sites for power production units; (2) improving site selection capabilities; (3) conducting market studies, economic analysis, and feasibility studies; and (4) diversifying their business to include wind measurements (1962-1981).

## SANDIA LABORATORIES

**Weapons**

- Since its establishment in 1949, Sandia has developed safe, reliable, deliverable, field-ready weapons using the nuclear devices developed by LANL and LLNL. Sandia's weapons research and development includes arming, fuzing, and firing systems; command and control systems; and the structural and aerodynamic designs. Significant advances in safety, security, and flexibility of those systems as well as in miniaturization of components and protection against hostile environments have been made. Sandia has also been instrumental in extending component shelf life, thus greatly reducing stock-pile maintenance costs. The Laboratory performs these functions for all nuclear weapons in the stockpile. Until about 1973, Sandia's activities were 100% defense related; today about 75% of the staff is engaged in defense activities. Since defense work is classified, representative unclassified examples of accomplishment cannot be supplied except for the nonweapon projects started within the last five-ten years.

**Nonweapons**

- In a program initiated in the early 1970s, Sandia has discovered a family of transparent electroptic ferroelectric ceramics based on lead lanthanum zirconate titanate (PLZT) and has developed unique solid-state devices based on these materials. The applications include image storage, processing, and display devices; light valves and shutters (e.g., flashblinders and welding goggles, spectral and variable density filters); and numeric displays. Over 20 companies and laboratories in the United States and abroad now have active research and development programs on PLZT materials and devices.
- After conducting systems studies of fossil and geothermal processes, Sandia developed more than two dozen devices and processes now widely used by industry. Examples are high-temperature microcircuits, coring devices, new drilling muds, new hardrock drill bits, and a downhole combustion device for injecting steam into oil-bearing formations. Since about 80% of this country's heavy oil deposits will be recovered using thermal energy, it is significant that downhole steam generators use less fuel, create less pollution, and recover more oil from greater depths than surface generators. Several commercial firms are in design and manufacture of the device (1974-1982).
- Sandia has managed a significant fraction of the national solar energy program. The Laboratory's systems studies and experience with costs of hardware construction and operation revealed market limitations that were not commonly recognized nor publicized. Over 20,000 industrial and political decision makers have been extensively briefed on the results of this work (1972 to present).
- Sandia's Combustion Research Facility was opened in 1981. Already, experimental results and computer codes from the combustion research program have been used by the automotive industry to modify engine designs for greater fuel efficiency, and theoretical analyses have enabled oil and power systems to devise a technique for significantly reducing a major pollutant product of combustion.
- In 1975 a patent was granted on Sandia's Hot Gas Solder Leveler, which, relative to other solder levelers, reduced process time by 90%, pollution by 95%, and power requirements by 60%. Several firms have manufactured the hundreds of Hot Gas Solder Levelers in use domestically and overseas; annual sales estimates are in the neighborhood of $20 million.
- Since the concept of using laminar airflow to create ultraclean and contamination-free environments was developed at Sandia in the early 1960s, numerous manufacturers have produced many thousands of clean rooms and work stations for medical, industrial, and other applications. Annual sales in the United States are estimated to exceed $100 million.
- Sandia has identified and developed understanding of very important long-term, low-level radiation damage dose-rate in polymeric materials used in nuclear power reactors (1978 to present). This work, which grew out of extensive radiation effects research, has resulted in the worldwide reexamination and rewriting of test methodology for qualification of materials used in nuclear power reactors.
- Experimental and analytical data that reduce the uncertainties in understanding several accidents in commercial nuclear power rectors have been developed here. The program uses Sandia's unique Annular Core Research Reactor (ACRR) as well as other specialized materials test

## SANDIA LABORATORIES (Continued)

facilities. This program has shown several hypotheses used in designing for future reactors to be incorrect. Also, the ACRR has allowed reactor safety experiments that produce more accurate assessments of reactor safety (1975 to present).

- Sandia has developed the technology for radiation-tolerant large-scale integrated circuits and transferred this technology to industry. Radiation-hardened microelectronics applications include national security, nuclear reactor instrumentation, satellite-based equipment, and the U.S. space program.
- New concepts and techniques in modular pulsed power, power conditioning, and power concentration that are leading to particle accelerators and similar devices capable of delivering extremely high energies and powers have been developed. These devices are finding important applications in studies of high-energy-density plasmas, the effects of intense radiation on materials, and directed-energy particle beams (1972 to present).

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# FINAL REPORT

of the

# MULTIPROGRAM LABORATORY PANEL

# ENERGY RESEARCH ADVISORY BOARD

## VOLUME II: SUPPORT STUDIES

Irving Spiewak
Miriam P. Guthrie
Jere P. Nichols
Elizabeth L. Preston
Colin D. West
Thomas J. Wilbanks
Beverly Y. Wilkes
Allyn C. Zerby

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Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
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## PREFACE

The final report of the Multiprogram Laboratory Panel of the Energy Research Advisory Board consists of three volumes. The present report — Volume II — was prepared by the Oak Ridge National Laboratory to provide supporting data and analyses for the Multiprogram Laboratory Panel.

The content of each of the three volumes is as follows:

**Volume I — Main Report**
- Executive Summary
- Introduction
- Overview of the Multiprogram National Laboratory Complex
- The Appropriate Roles and Missions of the Laboratories vis-a-vis Universities and Industry
- The Scientific and Technological Capabilities of the Laboratories
- The Department's Policies and Procedures with Respect to the Laboratories
- The Effectiveness of the Department's Use of the Laboratories in Meeting its Energy Objectives
- Alternative Strategies for Making Use of the Laboratories in a Constrained Budgetary Environment
- Additional Considerations

**Volume II — Support Studies**
- Summary
- Report of Statistical Data on the Multiprogram Laboratories
- Examples of National Laboratory Use in Foreign Countries
- Domestic Models for National Laboratory Utilization
- Relationships of Laboratories With Industry and Universities
- Uses of Laboratories for Training Industrial R&D Personnel
- Legal Mandates and Constraints on the National Laboratories
- Appendix A — Facts About Harwell, CEN-Saclay, TNO, Studsvik, and JAERI-Tokai
- Appendix B — The Requirements Boards of the United Kingdom Department of Industry
- Appendix C — Impact of President's FY 1983 Budget
- Appendix D — The PNL Experiment

**Volume III — Appendices**
- Appendix I — Laboratory Goals and Missions Statements
- Appendix II — Laboratory Program Mix
- Appendix III — Class Wavier of Government Rights in Inventions Arising from the Use of DOE Facilities by or for Third Party Sponsors
- Appendix IV — DOE 4300.2: Research and Development Work Performed for Others
- Appendix V — Procedure for New Work Assignments at R&D Laboratories
- Appendix VI — DOE 5800.1: Research and Development Laboratory Technology Transfer Program

## HIGHLIGHTS

- Nine multiprogram laboratories (MPLs), handling close to 50% of the DOE research and development (R&D) budget and about 9% of the total federal R&D, were reviewed. About half of this expenditure is related to nuclear weapons development.
- The laboratories conduct about 70% of DOE's weapons development, about 50% of the fundamental science and environmental research, and about 24% of the energy-related R&D. About 39% of the laboratory funding, included above, supports contracting with the private sector.
- The laboratories are an extensive and diverse set of facilities; work done at the laboratories range from basic research to engineering development, with the fraction of effort in each category varying from laboratory to laboratory.
- Each laboratory has its own special character and technical strengths that have evolved over several decades of support for the atomic energy program and more recently in response to broader energy R&D assignments.
- Changes in emphasis in DOE are reflected in the laboratories' budgets; in FY 1982 there was a reduction in overall manpower by about 6% and a reduced level of effort of about 8% (taking inflation effects into account).
- There are reductions in overall dollar and personnel levels projected in FY 1983, based on the President's budget, that affect several laboratories very severely (Pacific Northwest Laboratory and Lawrence Berkeley Laboratory) and continue the downward trend for a number of the laboratories (Ames Laboratory, Argonne National Laboratory, Brookhaven National Laboratory, and Oak Ridge National Laboratory) with specific problem areas in environmental activities, conservation, solar and fossil programs.
- Contrasted with the other MPLs, the three laboratories principally involved with defense activities have had slight increases in their total budgets in FY 1981 and 1982, reflecting a shift in priorities toward the development of weapons. In FY 1983, projected obligations are down for all laboratories.
- Other industrialized countries have developed and maintained an equivalent national laboratory structure and have coped with changes in level of support and in orientation more-or-less successfully and without shutting down facilities.

- The major trend in foreign laboratories has been toward expanded service to, and involvement with, their national industrial sector. The resources represented by their national laboratories have been recognized as important to their continuing economic health and competitiveness, and ways have been found to use these resources in commercial settings consistent with the different public-sector — private-sector relationships that exist in each of the countries.

- While the MPLs are all government owned and contractor operated (GOCO), other agencies provide examples of alternative management structures. Successful laboratories seem less dependent upon structural status (i.e., GOCO, entirely private, government owned-government operated, or federal contract research center) than upon the presence of enlightened management that understands the research process and provides a favorable environment for quality work.

- Positive and negative aspects are associated with a number of approaches to key management questions such as the balance between a highly focused or a broad technical effort, allowing substantial work-for-others or being very restrictive regarding such work, encouraging technology transfer or being highly internalized, and budgeting on a level-of-effort basis or on a project-by-project approach. No single best approach seems to emerge from a consideration of these and other options. A wide variety of operating styles are being used by other government agencies; some aspects of other agencies' experiences may suggest possibilities that could be adapted to MPLs.

- Currently, the interaction between the laboratories and both industry and universities occurs on many fronts: subcontracts, use of specialized MPL facilities, personnel interchange, training of industry R&D personnel, promotion of technology transfer, specialized communications services, and occasional partnership arrangements. Beyond current contacts, there are prospects for increasing and facilitating these interactions through programs that provide incentives and greater opportunities to assist universities and industry.

- Legislation provides, in principle, a great degree of flexibility in doing support work-for-other, non-DOE clients: federal agencies, state and local governments, universities, and the private-sector. Management guidance from DOE tends to limit this type of support primarily to services unavailable from the private sector.

- The principal problems involve subjective judgments about the degree of laboratory competition with the private sector and possible interference with DOE work. Other issues involve patent policy, protection of industry proprietary data, industry or university use of laboratory facilities, and lack of financial incentives for broadened outside use of the laboratories' capabilities.

# 1. SUMMARY

In response to a request by the Multiprogram Laboratory (MPL) Panel of the Energy Research Advisory Board, a series of brief papers were prepared to provide background and analyses of selected issues to assist the Panel in its deliberations. These papers have been brought together as sections of a single document of supporting studies to accompany the Panel report, together with other related materials included as appendices. The papers were prepared by the staff of the Oak Ridge National Laboratory with the assistance of the Department of Energy (DOE) and a number of other individuals and institutions.

The principal role of these studies has been to stimulate development of the Panel's views in response to the charge provided by the Deputy Secretary of DOE. However, the material that has been assembled provides a new and somewhat differing perspective on the MPLs with possible use beyond the Panel's deliberations; therefore, they are being published for future reference.

Although DOE lists twelve MPLs, this review focuses upon the nine laboratories with the most diversity in their operational roles and program content. The remaining three — Hanford Engineering Development Laboratory, Idaho National Engineering Laboratory, and the Savannah River Laboratory — are strongly oriented to a single program, and although they exhibit many of the characteristics of the others, they were not considered in detail by the Panel. The nine MPLs that were reviewed in-depth receive close to one-half of the DOE research and development (R&D) funds (about $2.5 billion in FY 1982) and about $450 million for additional R&D work from other sources, both federal and nonfederal. The nine MPLs are currently responsible for about 9% of total federal R&D funding; therefore, they have grown to represent a significant commitment of the research and technology development resources of the nation. Total full-time equivalent staff at the MPLs is currently about 40,000 (about 6% of U.S. R&D performers).

The MPLs receive considerable non-DOE funding (15% of total budget) and commit a significant fraction (currently 39%) of the funds that are received to outside sources — both industry (37%) and universities (2%). However, there is a significant downward trend in projected funding at the laboratories in FY 1983, which is particularly pronounced in Conservation, Solar, and Fossil programs. In view of the changing fiscal climate, as well as changing federal policies regarding R&D roles for the federal government and the substantial fraction of the national R&D capability that is affected, the existing and prospective future roles for MPLs are reviewed in some detail and, in Sect. 3, compared with examples from other developed nations, namely the United Kingdom, France, the Netherlands, Sweden, and Japan.

These nations have established national laboratories that have many similarities with MPLs, although the political, social, economic, and institutional settings may differ considerably depending upon the different cultures in which these foreign laboratories operate. Despite these detailed differences, there are common problems that can be identified as well as solutions that have potential for the United States. For example, there are illustrations of several occasions when changing external needs have required the laboratories to make a major change in their focus and diversify their output into new areas. Successful shifts of this nature seem to require long lead times, management flexibility, and strong support from the government sponsor, if they are to be accomplished without a serious loss of quality.

A major trend in the foreign laboratories that were reviewed has been toward expanded service to, and involvement with, the industrial sector. The resources represented by these foreign laboratories were recognized as important to the continuing economic health of their countries, and ways have been found to use these resources in commercial settings that are consistent with the different public-sector — private-sector relationships that exist in each of the countries. A variety of mechanisms have been established to increase the flow of technology from these foreign laboratories to the commercial sector, and collaboration often goes beyond the boundaries of currently accepted practices in the United States regarding government-industry relationships. Nevertheless, the obvious conclusion is that our major industrial competitors recognize the value of the output possible from their national laboratories and have taken steps to increase their laboratory-industry coupling.

Among the devices employed is the large-scale use of industry scientists to perform work at the laboratories, thereby increasing person-to-person contact, extensive contracting from industry in determining the research and technology development agendas for the laboratories, and government assignment to the laboratories of specific areas in which to work that are supportive of industrial needs.

Although certain foreign practices would be difficult for the United States to adopt, the range of management approaches that have been used by federal agencies for their R&D needs is quite broad, from fully government institutions to entirely private, contractor-owned — contractor-operated arrangements. These varied institutional approaches each have strengths and characteristics that make them particularly suitable to specific missions and agency styles.

The MPLs are all government-owned — contractor-operated (GOCO) institutions that have been established for at least 30 years or more, with their initial roles focused on various aspects of atomic energy. Particularly in the last decade, these roles have been expanded to include all aspects of energy R&D, with a consequent need to extend and diversify their human and physical resources. This was also a period in which their federal sponsor was changing, with new missions and new people added, as well as rapid and frequent management changes and shifts in federal policy overlaid upon the traditional relationships between the Atomic Energy Commission, the laboratories, and others.

The GOCO mechanism has permitted the laboratories to respond to these changes with relatively minor perturbations and with a degree of local laboratory management creativity in maintaining their responsiveness to federal needs. While these strengths of the GOCO arrangement have been demonstrated, further refinements and variations are possible in the management approach which is discussed in some detail in Sect. 4.

From a consideration of other agencies' experiences and the private sector, it appears there are positive and negative aspects associated with a number of approaches to key management questions: the balance between a highly focused or a broad technical effort, allowing substantial work-for-others or being restrictive regarding such work, encouraging technology transfer or being highly internalized, and budgeting on a level-of-effort basis or on a project-by-project approach. No single best approach seems to emerge from a consideration of these and other topics. It does appear that a clear understanding of the mission of the laboratory by both the sponsor and the laboratory management, coupled with an understanding of the operating requirements at all levels, and development of a spirit of partnership in working toward well-understood goals are important ingredients leading to a successful and productive laboratory.

An important part of MPL's missions calls for mutually constructive interaction with industry and universities. Currently, the interaction between the laboratories and both industry and universities occurs on many fronts: subcontracts, use of specialized MPL facilities, personnel interchange, training of industry R&D personnel, promotion of technology transfer, specialized communications services, and occasional partnership arrangements. Beyond current contacts, prospects exist for increasing and facilitating these interactions through programs that provide incentives and greater opportunities to assist universities and industry.

In considering possible variations in the way in which the laboratories would relate to industry, it is instructive to look carefully at the special relationships that have been established at the Pacific Northwest Laboratory (PNL). At PNL, some facilities are owned by the operating contractor, and a special Use Permit allows use of these private facilities and government-owned property in custody of the contractor to perform R&D activities for the contractor (Battelle Memorial Institute). This allows industry and universities to have easy access to PNL's facilities and gives PNL the ability to access other research sectors through private contract research. Accounting systems have been established to provide for full cost recovery for such work.

In addition to the examination and assessment of various management approaches, the formal, legal framework for the laboratory-federal sponsor relationship has been analyzed (Sect. 7), as well as the implementing instructions for the various legislative mandates.

Although the legislative definition of the scope of the national laboratories is quite broad, DOE has established policy guidelines, in part, to define the laboratories' research roles as they relate to the roles of industries and universities. DOE Order 5000.1 specifies the work appropriate for the MPLs as that which "requires use of skills or facilities uniquely available at the laboratories, or is determined not to be within the capability and interest of university or industry to perform, or requires a fast startup or multidisciplinary approach not readily available to the private sector to meet an urgent national research and developmental need" (DOE 1980). A May 5, 1982, memorandum from Under Secretary Guy W. Fiske provides detailed guidance on the MPLs' missions and goals, which include "perform[ing] research and development on long-term, high-risk, high-payoff energy technologies beyond the development horizon of the private sector" and "perform[ing] research and development in areas where industry and, where relevant, universities would have an apparent or actual conflict of interest" (Fiske 1982).

Generally, the legislation and implementing guidance to the laboratories provides in principle, a wide degree of flexibility in doing support work for other non-DOE clients: federal agencies, state and local government, universities, and private sector. The major problems involve subjective judgements about the degree of laboratory competition with the private sector and possible interference with DOE work. Other issues involve patent policy, protection of industry proprietary data, industry or university use of laboratory facilities, and lack of financial incentives for broadened outside use of the laboratories' capabilities. For example, although DOE's patent policies are often cited as an obstacle to having industry work more closely with the laboratories, Public Law 96-517 was passed in 1981, and it specified changes in government patent policy to make it easier for small businesses or nonprofit organizations to retain title to inventions conceived under DOE funding, subject to certain government march in rights. Further incentives are being considered, including a provision that would allow the laboratories to retain rights to federally funded inventions.

In the sections which follow, these points are elaborated in some detail. Also included are appendices treating the impacts of the FY 1983 budget and the special features of the management arrangements at PNL.

## REFERENCES FOR SECTION 1

Fiske, Guy W. May 5, 1982. *Policy Guidance for FY 1983-1988 Multiprogram Laboratory Institutional Planning.* U.S. Department of Energy memorandum.

U.S. Department of Energy (DOE). June 25, 1980. *Institutional Planning Process.* DOE Order 5000.1.

## 2. REPORT OF STATISTICAL DATA ON THE MULTIPROGRAM LABORATORIES

**I. Spiewak and M. P. Guthrie**

This section presents statistical data on the multiprogram laboratories (MPL) for the period 1970-1982 within the framework of statistics on research and development (R&D) expenditures by the Atomic Energy Commission/Energy Research and Development Administration/Department of Energy (AEC/ERDA/DOE) and the United States as a whole. The main sources of these data are National Science Foundation (NSF) reports, DOE reports and staff information, and the Institutional Plans of each laboratory. Because budgets are continually changing and budget categories are treated differently by various offices, some minor inconsistencies exist within the data base. However, the data presented herein have been reviewed and are believed to present a consistent picture.

Table 2.1 presents the trends in R&D sources of funds and performers for 1970 through 1982. The nine DOE laboratories increased their share of the federal R&D budget from about 5.9% in 1970 to 7.3 to 9.1% in 1977-1981. On the other hand, their share of the AEC/ERDA/DOE R&D budget declined from about 65% in 1970 to about 34 to 43% in 1977-1981; this decline reflected a large growth in energy R&D performed by industry rather than a reduction in MPL work. It appears that the laboratories' share of the DOE FY 1982 R&D budget may be as high as 49%; this reflects increases in programs implemented largely at the labs (e.g., Defense) as opposed to reductions in programs implemented primarily in industry (e.g., Solar and Fossil).

Table 2.2 displays the "market share" of performers of DOE R&D during 1979-1982. The industrial market share fell from 33% in 1979 to an estimated 28% in 1982, while the university share increased from 5.6% in 1979 to an estimated 6.0% in 1982. The nine laboratories' share increased from 40% in 1979 to an estimated 49% in 1982, but if laboratory procurements and subcontracts to industry and universities were deleted from their budgets, then the range of the laboratories' market share would be reduced to 24 to 27%.

Table 2.3 provides details of laboratory subcontracts and procurements. They were in the range of 33-39% of operating budgets during FY 1978 to FY 1981, and increasing during that time. Of this percentage, subcontracts to universities accounted for 1.3 to 1.6 of laboratory budgets.

Data on industrial performance of energy R&D during 1972 to 1980 are shown in Table 2.4. During this period, the amount of increase in current-dollar budgets was 5.5-fold. The laboratory budgets increased about threefold during this period (Table 2.1). DOE supported 42% of this industry work (not counting laboratory subcontracts) in 1979 and 34% in 1980; data for the preceding year were not available. Thus, it appears that over half the increase in industrial R&D between 1972 and 1980 was privately funded.

### Table 2.1. Trends in R&D sources of funds and performers
(Current $ in millions)

| Year | Total R&D budget | Federal Government | | Industry | | Universities and colleges | | Other nonprofit institutions | | Nine multiprogram DOE laboratories | Total AEC/ERDA/DOE R&D Budgets[a] | Laboratory funding/ AEC/ERDA/DOE funding (%) | Lab/federal funding (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Funder | Performer | Funder | Performer | Funder | Performer | Funder | Performer | | | | |
| 1970 | 26,072 | 14,830 | 4,017 | 10,444 | 18,067 | 461 | 3,072 | 337 | 916 | 869[b] | 1,346 | 65[b] | 5.9 |
| 1971 | 26,653 | 14,941 | 4,205 | 10,822 | 18,320 | 529 | 3,216 | 361 | 912 | | 1,303 | | |
| 1972 | 28,429 | 15,760 | 4,542 | 11,710 | 9,552 | 574 | 3,383 | 385 | 952 | | 1,298 | | |
| 1973 | 30,665 | 16,346 | 4,709 | 13,293 | 21,249 | 615 | 3,701 | 413 | 1,006 | | 1,363 | | |
| 1974 | 32,814 | 16,800 | 4,861 | 14,878 | 22,887 | 677 | 3,888 | 459 | 1,178 | | 1,489 | | |
| 1975 | 35,169 | 18,065 | 5,310 | 15,820 | 24,187 | 749 | 4,396 | 535 | 1,276 | | 2,047 | | |
| 1976 | 38,935 | 19,833 | 5,688 | 17,694 | 26,997 | 808 | 4,874 | 600 | 1,376 | 1,456[c] | 2,464 | 42[b,c] | 7.3 |
| 1977 | 42,923 | 21,674 | 6,053 | 19,696 | 29,928 | 881 | 5,447 | 672 | 1,495 | 1,769[c] | 3,536 | 38[b,c] | 8.2 |
| 1978 | 48,023 | 23,893 | 6,856 | 22,336 | 33,164 | 1,028 | 6,331 | 766 | 1,672 | 2,025[c] | 4,245 | 34[b,c] | 8.6 |
| 1979[d] | 54,215 | 26,556 | 7,497 | 25,638 | 37,606 | 1,183 | 7,118 | 838 | 1,994 | 2,324[c] | 4,639 | 40[b,c] | 8.8 |
| 1980[e] | 61,127 | 29,302 | 8,052 | 29,475 | 42,750 | 1,385 | 8,150 | 965 | 2,175 | 2,585[c] | 4,754 | 39[b,c] | 8.8 |
| 1981[e] | 69,065 | 32,665 | 8,965 | 33,865 | 49,150 | 1,485 | 8,600 | 1050 | 2,350 | 2,923[c] | 4,927 | 43[b,c] | 9.1 |
| 1982[e] | | | | | | | | | | 2,938[c] | 4,690 | 49[b,c] | |

[a] Note that the AEC/ERDA/DOE R&D budgets in this table (reported by National Science Foundation) differ from those obtained from DOE and laboratory sources (Tables 2.5 to 2.11).

[b] Does not include work for sponsors other than AEC/ERDA/DOE.

[c] Obtained from Tables 2.5 to 2.11.

[d] Preliminary.

[e] Estimated.

Sources of data: NSF 81-311, other NSF reports, DOE reports, and DOE staff information.

Table 2.2. Distribution of DOE R&D budget obligation by performer
($ in millions)

| FY | Total | Intramural | Industrial firms | Universities and colleges | Other nonprofit | State and local governments | Foreign | All FFRDCs[a] | Nine laboratories (Gross)[b] | Nine laboratories (Net)[c] |
|---|---|---|---|---|---|---|---|---|---|---|
| 1979 | 4638.8 | 361.9 | 1547.9 | 260.1 | 57.0 | 15.1 | 3.5 | 2393.4 | 2042 | 1344 |
| 1980 | 4753.7 | 473.6 | 1377.0 | 285.0 | 58.5 | 22.4 | 14.2 | 2523.0 | 2237 | 1405 |
| 1981[d] | 4926.7 | 516.7 | 1314.0 | 289.1 | 61.1 | 18.7 | 20.7 | 2706.3 | 2495 | 1553 |
| 1982[d] | 4690.2 | 366.8 | 1298.8 | 280.4 | 48.4 | 3.4 | 9.1 | 2683.3 | 2499 | |

[a] Federally funded research and development centers.

[b] From Tables 2.8 to 2.11. Note that these numbers are inconsistent with NSF's data (i.e., NSF does not count all of DOE's "R&D budget" as R&D).

[c] Net budget equals gross budget from previous column after subtraction of subcontracting and procurement of Table 2.3.

[d] Estimated.

Source: National Science Foundation except as noted above.

Table 2.3. Laboratory subcontracting and procurements
($ in millions)
(Percentages of total operating budget)

| Laboratories | Total operating budget and type of procurement or subcontract | FY 1978 | | FY 1979 | | FY 1980 | | FY 196 | |
|---|---|---|---|---|---|---|---|---|---|
| Ames | Total operating | 12.2 | | 13.5 | | 15.3 | | 17.6 | |
| | Procurement | 2.8 | (22.9) | 3.5 | (25.9) | 5.2 | (34.0) | 4.7 | (26.7) |
| | University subcontracts | 0.2 | ( 1.6) | 0.1 | ( 0.7) | 0.1 | ( 0.6) | 0.6 | ( 3.4) |
| | Other subcontracts | ___ | ( 0.0) | 0.1 | ( 0.7) | 0.1 | ( 0.3) | 0.6 | ( 3.4) |
| | Total subcontracting and procurements | 3.0 | (24.6) | 3.7 | (27.4) | 5.3 | (34.9) | 5.9 | (33.5) |
| ANL [a] | Total operating | 183.6 | | 188.7 | | 199.2 | | 220.6 | |
| | Procurement | 25 | (14.0) | 30 | (16.0) | 39 | (19.5) | 37 | (17.0) |
| | University subcontracts | 3.7 | ( 2.0) | 1.9 | ( 1.0) | 2 | ( 1.0) | 2.2 | ( 1.0) |
| | Other subcontracts | 13 | ( 7.0) | 36 | (19.0) | 46 | (23.0) | 60 | (27.0) |
| | Total subcontracting and procurements | 42 | (23.0) | 68 | (36.0) | 87 | (43.5) | 99 | (45.0) |
| BNL [b] | Total operating | 112.8 | | 119.6 | | 138.3 | | 151.9 | |
| | Procurement | 27.2 | (24.1) | 28.2 | (23.6) | 35.3 | (25.5) | 36.5 | (24.0) |
| | University subcontracts | 0.7 | ( 0.6) | 1.5 | ( 1.3) | 1.4 | ( 1.0) | 1.9 | ( 1.2) |
| | Other subcontracts | 6.1 | ( 5.4) | 5.3 | ( 4.4) | 7.3 | ( 5.3) | 6.6 | ( 4.3) |
| | Total subcontracting and procurements | 34 | (30.0) | 35 | (29.0) | 44 | (32.0) | 45 | (29.6) |
| LBL [c] | Total operating | 76.6 | | 88.0 | | 93.1 | | 98.7 | |
| | Procurement | 12 | (16.0) | 12 | (14.0) | 13 | (13.0) | 11 | (11.0) |
| | University subcontracts | 0.8 | ( 1.0) | 2 | ( 2.0) | 2 | ( 2.0) | 2 | ( 2.0) |
| | Other subcontracts | 2.0 | ( 3.0) | 4 | ( 4.0) | 6 | ( 6.0) | 5 | ( 5.0) |
| | Total subcontracting and procurements | 14.8 | (20.0) | 18 | (20.0) | 21 | (22.0) | 18 | (18.0) |
| LLNL [d] | Total operating | 307.9 | | 320.3 | | 363.6 | | 390.5 | |
| | Procurement | 44 | (14.4) | 48 | (14.8) | 54 | (14.8) | 59 | (15.2) |
| | University subcontracts | 1.5 | ( 0.5) | 1.6 | ( 0.5) | 1.8 | ( 0.5) | 1.9 | ( 0.5) |
| | Other subcontracts | 11 | ( 3.6) | 12 | ( 3.7) | 13 | ( 3.7) | 15 | ( 3.8) |
| | Total subcontracting and procurements | 57 | (18.5) | 61 | (19.0) | 69 | (19.0) | 76 | (19.5) |
| LANL [e] | Total operating | 287.3 | | 330.6 | | 375.4 | | 442.2 | |
| | Procurement | 90.5 | (31.5) | 100.7 | (30.5) | 115.8 | (30.8) | 130.9 | (29.6) |
| | University subcontracts | 4.3 | ( 1.5) | 1.4 | ( 0.4) | 1.6 | ( 0.4) | 1.8 | ( 0.4) |
| | Other subcontracts | 17.4 | ( 6.1) | 24.1 | ( 7.3) | 27.7 | ( 7.4) | 31.3 | ( 7.1) |
| | Total subcontracting and procurements | 112.2 | (39.1) | 126.2 | (38.2) | 145.1 | (38.7) | 164 | (37.1) |
| ORNL [f] | Total operating | 247.0 | | 277.5 | | 316.6 | | 336.7 | |
| | Procurement | 27 | (11.0) | 30 | (11.0) | 29 | ( 9.0) | 27 | ( 8.0) |
| | University subcontracts | 3.7 | ( 1.5) | 8.3 | ( 3.0) | 9.5 | ( 3.0) | 11.8 | ( 3.5) |
| | Other subcontracts | 26 | (10.5) | 42 | (15.0) | 63 | (20.0) | 61 | (18.0) |
| | Total subcontracring and procurements | 57 | (23.0) | 80 | (29.0) | 101 | (32.0) | 99 | (29.5) |

Table 2.3. (continued)

| Laboratories | Total operating budget and type of procurement or subcontract | FY 1978 | | FY 1979 | | FY 1980 | | FY 1981 | |
|---|---|---|---|---|---|---|---|---|---|
| PNL[g] | Total operating | 109.5 | | 115.7 | | 128.6 | | 145.6 | |
| | Procurement | 12 | (11.0) | 12 | (10.0) | 14 | (11.0) | 15 | (10.0) |
| | University subcontracts | 1.2 | ( 1.0) | 1.2 | ( 1.0) | 1.0 | ( 1.0) | 1.5 | ( 1.0) |
| | Other subcontracts | 9 | ( 8.0) | 13 | (11.0) | 27 | (21.0) | 34 | (23.0) |
| | Total subcontracting and procurements | 22 | (20.0) | 26 | (22.0) | 42 | (33.0) | 50 | (34.0) |
| Sandia | Total operating | 390.2 | | 451.6 | | 524.4 | | 605.2 | |
| | Procurement | 181 | (46.4) | 236.9 | (52.4) | 275.9 | (52.6) | 320.8 | (53.0) |
| | University subcontracts | 7 | ( 1.8) | 8.4 | ( 1.9) | 11.8 | ( 2.2) | 15.1 | ( 2.5) |
| | Other subcontracts | 40.7 | (10.4) | 34.1 | ( 7.6) | 30.3 | ( 5.8) | 47.2 | ( 7.8) |
| | Total subcontracting and procurements | 228.7 | (58.6) | 279.4 | (61.9) | 318 | (60.6) | 383.1 | (63.3) |
| Total | Total operating | 1727 | | 1906 | | 2155 | | 2409 | |
| | Procurement | 421 | (24.3) | 501 | (26.3) | 581 | (27.0) | 642 | (26.7) |
| | University subcontracts | 23 | ( 1.3) | 26 | ( 1.4) | 31 | ( 1.4) | 39 | ( 1.6) |
| | Other subcontracts | 125 | ( 7.2) | 171 | ( 9.0) | 220 | (10.2) | 261 | (10.8) |
| | Total subcontracting and procurements | 569 | (32.9) | 698 | (36.6) | 832 | (38.6) | 942 | (39.1) |

[a] Argonne National Laboratory.
[b] Brookhaven National Laboratory.
[c] Lawrence Berkeley Laboratory.
[d] Lawrence Livermore National Laboratory.
[e] Los Alamos National Laboratory.
[f] Oak Ridge National Laboratory.
[g] Pacific Northwest Laboratory.
Source: Institutional Plans (estimates).

### Table 2.4. Funds for industrial energy R&D performance by primary energy source 1972-1980 (Current $ in millions)

| Primary energy source | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980[a] (Projected) |
|---|---|---|---|---|---|---|---|---|---|
| Fossil fuels | | | | | | | | | |
| Oil | *b* | 297 | 329 | 333 | 381 | 454 | *b* | 554 | 582 |
| Gas | *b* | 51 | 74 | 66 | 68 | 94 | *b* | 113 | 118 |
| Shale | *b* | 12 | 18 | 19 | 24 | 35 | *b* | 20 | 22 |
| Coal | *b* | 49 | 65 | 109 | 127 | 177 | *b* | 287 | 302 |
| Synthetic fossil fuels | *b* | *b* | 21 | 50 | 74 | 116 | *b* | 215 | 227 |
| Mining | *b* | *b* | 5 | 9 | 10 | 9 | *b* | 1 | 1 |
| Other | *b* | *b* | 39 | 50 | 43 | 52 | *b* | 71 | 74 |
| Other fossil fuels | *b* | 29 | 30 | 23 | 5 | 5 | *b* | 51 | 54 |
| Total | *b* | 438 | 581 | 659 | 732 | 942 | 860 | 1312 | 1380 |
| Nuclear | | | | | | | | | |
| Fission | *b* | 476 | 567 | 659 | 741 | 852 | *b* | 798 | 848 |
| Fusion | *b* | 25 | 34 | 41 | 58 | 83 | *b* | 119 | 84 |
| Total | *b* | 501 | 601 | 700 | 799 | 935 | 1016 | 917 | 932 |
| All other energy | | | | | | | | | |
| Geothermal | *b* | 1 | 2 | 6 | 13 | 24 | *b* | 160 | 213 |
| Solar | *b* | 2 | 7 | 19 | 43 | 65 | *b* | 347 | 458 |
| Conservation and utilization | *b* | *b* | 137 | 435 | 528 | 694 | *b* | 731 | 966 |
| All other sources | *b* | 67 | 76 | 64 | 85 | 116 | *b* | 429 | 457 |
| Total | | 70 | 222 | 524 | 669 | 899 | 1150 | 1667 | 2094 |
| Total | 750 | 1009 | 1404 | 1883 | 2200 | 2776 | 3026 | 3896[c] | 4406[d] |

[a] Projected.

[b] Category not available for reporting purposes.

[c] Includes 1548 from DOE (see Table 2.2).

[d] Includes 1377 from DOE (see Table 2.2).

Source: National Science Foundation.

Tables 2.5 to 2.12 present, by laboratory and program breakdowns, the laboratory budgets for FY 1976 to FY 1982. Table 2.13 presents the same data on laboratory budgets as Table 2.12, except in constant 1981 dollars. A period of very slow growth occurred between FY 1978 and FY 1981, with a decline in FY 1982. Table 2.14 explains which subprograms are included in each category of the earlier tables. The DOE budgets in Tables 2.5 to 2.12 are obtained from the DOE budget highlight documents. They differ from the DOE R&D budgets reported by NSF (Table 2.2) in that NSF does not include demonstration and construction funds.

Budget and employment trends (Table 2.15) reflect a minimum of activity at the laboratories from 1970-1974 following the commercialization of nuclear power in the 1960s and prior to the expanded energy mission of the middle to late 1970s. Table 2.16, giving the budget trends of each laboratory, presents another crosscut of the budget. Tables 2.5 to 2.11, and Table 2.17 gives the same data in constant 1981 dollars. The individual MPLs vary considerably in their budget trends over the period from 1976 to 1982.

Table 2.18 is an attempt to analyze the MPLs's role in DOE programs for FY 1981 and FY 1982. This table shows that the MPLs did 70% of DOE Defense R&D in FY 1981, comprising 42% of the laboratories' budgets. This increased to 73% of DOE's Defense R&D budget in FY 1982 comprising 49% of the laboratories' budgets. They perform about 50% of the research sponsored by the Office of Energy Research, comprising 24 to 25% of their budgets. The laboratories also do about half of the environmental R&D, a relatively small program. The laboratories perform 22 to 24% of the Energy Supply and Conservation R&D, which includes only 11 to 13% of the Fossil program. This type of R&D declined from 25.8% of the laboratories' DOE budget in FY 1981 to 19.4% in FY 1982. Considering only nondefense programs, the nine-laboratory budget for FY 1981 would be $1,454 million, 34% of the DOE nondefense R&D budget of $4,323 million. This declined to $1,289 million in FY 1982, 37% of the DOE nondefense R&D budget of $3,473 million.

Work for other government agencies is a significant part of the laboratory programs (Table 2.19). In 1976 to 1978, work for others constituted 11.4 to 11.7% of the total laboratory budgets. In 1981 and 1982, it has constituted 15.1% of the budget with most of the increase attributable to the Department of Defense programs.

Another perspective on market share of DOE energy R&D is presented in Tables 2.20 and 2.21. These data, which are derived from DOE program offices, show that other DOE laboratories (other than the nine MPLs) are very significant R&D performers at 23-26% of the energy R&D budgets, and they explicitly show the share of the program performed by federal non-DOE labs at 4%. The market share captured by industry and other decreases from 38% in FY 1981 to 30% in FY 1982. A large part of this decrease is in demonstration programs. The DOE laboratories increase their market share from FY 1981 to FY 1982, although the absolute level of funding decreases.

Table 2.5. ERDA budget analysis, obligations for FY 1976
($ in millions)

| | ERDA budget | Ames | ANL | BNL | LBL | LLNL | LANL | ORNL | PNL | Sandia | Total laboratories | Laboratories/ ERDA (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Defense activities | 850 | 0 | 3 | 0 | 0 | 178 | 146 | 0 | 2 | 238 | 567 | 67 |
| General science | 246 | 1 | 22 | 34 | 39 | 0 | 21 | 14 | 0 | 0 | 131 | 53 |
| Solar, geothermal, electrical energy, and storage | 182 | 0 | 1 | 5 | 4 | 4 | 7 | 1 | 4 | 12 | 39 | 21 |
| Magnetic fusion | 167 | 0 | 2 | 2 | 1 | 26 | 17 | 27 | 1 | 0 | 76 | 46 |
| Nuclear | 817 | 0 | 80 | 1 | 0 | 12 | 27 | 47 | 20 | 6 | 193 | 24 |
| Environment | 205 | 0 | 16 | 13 | 4 | 8 | 9 | 35 | 18 | 2 | 110 | 54 |
| Supporting research | 145 | 8 | 23 | 20 | 11 | 1 | 2 | 39 | 4 | 0 | 108 | 74 |
| Fossil | 398 | 0 | 10 | 1 | 0 | 6 | 0 | 4 | 0 | 4 | 25 | 7 |
| Conservation | 39 | 0 | 8 | 1 | 1 | 1 | 2 | 2 | 0 | 1 | 15 | 38 |
| Other | ---- | 0 | 3 | 2 | 1 | 2 | 2 | 5 | 11 | 0 | 26 | --- |
| ERDA total | 3049 | 9 | 168 | 84 | 61 | 238 | 233 | 174 | 60 | 263 | 1286[a] | 42 |
| Work-for-others | | 1 | 10 | 11 | 10 | 27 | 18 | 28 | 14 | 51 | 170 | |
| Total laboratories | | 10 | 178 | 95 | 71 | 265 | 251 | 202 | 74 | 314 | 1456 | |

[a] Total includes a reduction of $4 million contracted between multiprogram laboratories.

Source: DOE Controller's Office, individual laboratories.

### Table 2.6. ERDA budget analysis, obligations for FY 1977
($ in millions)

| | ERDA budget | Ames | ANL | BNL | LBL | LLNL | LANL | ORNL | PNL | Sandia | Total laboratories | Laboratories/ ERDA (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Defense activities | 924 | 0 | 0 | 0 | 0 | 194 | 164 | 5 | 4 | 289 | 656 | 71 |
| General science | 373 | 1 | 24 | 49 | 45 | 2 | 27 | 14 | 0 | 0 | 162 | 43 |
| Solar, geothermal, electrical energy, and storage | 405 | 0 | 3 | 7 | 6 | 5 | 11 | 5 | 8 | 28 | 73 | 18 |
| Magnetic fusion | 304 | 0 | 3 | 2 | 4 | 36 | 20 | 43 | 1 | 0 | 109 | 37 |
| Nuclear | 1187 | 0 | 86 | 1 | 0 | 11 | 36 | 55 | 27 | 9 | 225 | 19 |
| Environment | 181 | 1 | 18 | 13 | 4 | 10 | 7 | 20 | 19 | 3 | 95 | 52 |
| Supporting research | 156 | 10 | 23 | 19 | 14 | 2 | 3 | 34 | 3 | 0 | 108 | 69 |
| Fossil | 483 | 1 | 8 | 1 | 1 | 8 | 1 | 7 | 1 | 8 | 36 | 7 |
| Conservation | 101 | 0 | 20 | 2 | 4 | 4 | 0 | 4 | 1 | 2 | 37 | 37 |
| Other | ____ | 0 | 4 | 3 | 2 | 4 | 28 | 24 | 9 | 0 | 74 | ... |
| ERDA total | 4114 | 13 | 189 | 97 | 80 | 276 | 297 | 211 | 73 | 339 | 1568[a] | 38 |
| Work-for-others | | 0 | 12 | 15 | 15 | 30 | 21 | 38 | 15 | 58 | 204 | |
| Total laboratories | | 13 | 201 | 112 | 95 | 306 | 318 | 249 | 88 | 397 | 1772 | |

[a] Total includes a reduction of $7 million contracted between multiprogram laboratories.

Source: DOE Controller's Office, individual laboratories.

Table 2.7. DOE budget analysis, obligations for FY 1978
($ in millions)

| | DOE budget | Ames | ANL | BNL | LBL | LLNL | LANL | ORNL | PNL | Sandia | Total laboratories | Laboratories/ DOE (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Defense activities | 1085 | 0 | 2 | 1 | 1 | 216 | 203 | 7 | 3 | 312 | 745 | 69 |
| General science | 397 | 1 | 26 | 59 | 41 | 1 | 27 | 18 | 0 | 0 | 173 | 44 |
| Solar, geothermal, electrical energy, and storage | 757 | 0 | 5 | 9 | 11 | 11 | 10 | 9 | 9 | 31 | 95 | 13 |
| Magnetic fusion | 325 | 0 | 2 | 2 | 11 | 57 | 22 | 57 | 1 | 1 | 153 | 47 |
| Nuclear | 1257 | 0 | 90 | 1 | 0 | 17 | 39 | 96 | 42 | 4 | 289 | 23 |
| Environment | 218 | 1 | 20 | 14 | 8 | 14 | 9 | 31 | 21 | 5 | 123 | 56 |
| Supporting research | 185 | 11 | 26 | 23 | 13 | 2 | 4 | 45 | 4 | 3 | 131 | 71 |
| Fossil | 695 | 1 | 23 | 1 | 1 | 7 | 5 | 14 | 1 | 10 | 63 | 9 |
| Conservation | 279 | 0 | 9 | 3 | 6 | 1 | 1 | 10 | 3 | 4 | 37 | 13 |
| Other | | 0 | 8 | 4 | 2 | 11 | 11 | 21 | 10 | 0 | 67 | |
| DOE total | 5198 | 14 | 211 | 117 | 94 | 337 | 330 | 308 | 94 | 370 | 1867[a] | 36 |
| Work-for-others | | 1 | 15 | 19 | 13 | 41 | 24 | 39 | 23 | 65 | 240 | |
| Total laboratories | | 15 | 226 | 136 | 107 | 378 | 354 | 347 | 117 | 435 | 2107 | |

[a] Total includes a reduction of $9 million contracted between multiprogram laboratories.

Source: Institutional Plans, individual laboratories.

Table 2.8. DOE budget analysis, obligations for FY 1979
($ in millions)

| | DOE budget | Ames | ANL | BNL | LBL | LLNL | LANL | ORNL | PNL | Sandia | Total laboratories | Laboratories/ DOE (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Defense activities | 1172 | 0 | 3 | 1 | 1 | 249 | 216 | 3 | 1 | 331 | 805 | 69 |
| General science | 431 | 1 | 24 | 79 | 49 | 2 | 29 | 13 | 0 | 0 | 197 | 46 |
| Solar, geothermal, electrical energy, and storage | 786 | 0 | 20 | 10 | 12 | 7 | 23 | 14 | 9 | 49 | 144 | 18 |
| Magnetic fusion | 356 | 0 | 3 | 2 | 9 | 88 | 19 | 47 | 0 | 2 | 170 | 48 |
| Nuclear | 1199 | 0 | 88 | 2 | 0 | 17 | 44 | 89 | 35 | 10 | 293 | 25 |
| Environment | 219 | 1 | 18 | 11 | 7 | 14 | 13 | 22 | 21 | 5 | 112 | 51 |
| Supporting research | 220 | 10 | 30 | 27 | 15 | 3 | 6 | 37 | 4 | 14 | 146 | 66 |
| Fossil | 757 | 1 | 19 | 2 | 1 | 9 | 3 | 7 | 2 | 17 | 61 | 8 |
| Conservation | 233 | 0 | 22 | 3 | 8 | 2 | 1 | 14 | 6 | 0 | 56 | 24 |
| Other | ___ | 1 | 15 | 3 | 2 | 1 | 21 | 14 | 18 | 1 | 76 | --- |
| DOE total | 5119 | 14 | 242 | 140 | 104 | 392 | 375 | 260 | 96 | 429 | 2042[a] | 40 |
| Work-for-others | | 1 | 15 | 22 | 12 | 55 | 32 | 43 | 26 | 77 | 282 | |
| Total laboratories | | 15 | 257 | 162 | 116 | 447 | 407 | 303 | 122 | 506 | 2324 | |

[a] Total includes a reduction of $13 million contracted between multiprogram laboratories.

Source: Institutional Plans, individual laboratories.

Table 2.9. DOE budget analysis, obligations for FY 1980
($ in millions)

| | DOE budget | Ames | ANL | BNL | LBL | LLNL | LANL | ORNL | PNL | Sandia | Total laboratories | Laboratories/ DOE (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Defense activities | 1273 | 0 | 4 | 0 | 2 | 259 | 212 | 6 | 4 | 356 | 843 | 66 |
| General science | 472 | 1 | 20 | 106 | 45 | 2 | 34 | 18 | 0 | 0 | 226 | 48 |
| Solar, geothermal, electrical energy, and storage | 837 | 0 | 23 | 11 | 16 | 8 | 21 | 17 | 18 | 59 | 173 | 21 |
| Magnetic fusion | 356 | 0 | 4 | 2 | 5 | 79 | 19 | 63 | 0 | 2 | 174 | 49 |
| Nuclear | 1226 | 0 | 103 | 1 | 0 | 19 | 39 | 88 | 21 | 16 | 277 | 23 |
| Environment | 235 | 1 | 21 | 11 | 8 | 17 | 9 | 33 | 23 | 3 | 126 | 54 |
| Supporting research | 252 | 10 | 37 | 35 | 22 | 4 | 8 | 38 | 5 | 7 | 166 | 66 |
| Fossil | 876 | 1 | 20 | 3 | 2 | 6 | 21 | 22 | 4 | 19 | 98 | 11 |
| Conservation | 301 | 0 | 24 | 5 | 10 | 2 | 4 | 14 | 5 | 1 | 65 | 22 |
| Other | —— | 1 | 12 | 5 | 2 | 19 | 24 | 16 | 26 | 5 | 110 | —— |
| DOE total | 5791 | 14 | 268 | 179 | 112 | 414 | 391 | 315 | 106 | 468 | 2247[a] | 39 |
| Work-for-others | | 1 | 18 | 27 | 18 | 55 | 42 | 53 | 30 | 103 | 347 | |
| Total laboratories | | 15 | 286 | 206 | 130 | 469 | 433 | 368 | 136 | 571 | 2594 | |

[a] Total includes a reduction of $12 million contracted between multiprogram laboratories.

Source: Institutional Plans, individual laboratories.

Table 2.10. DOE budget analysis, obligations for FY 1981
($ in millions)

| | DOE budget | Ames | ANL | BNL | LBL | LLNL | LANL | ORNL | PNL | Sandia | Total laboratories | Laboratories/ DOE (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Defense activities | 1505 | 0 | 5 | 0 | 2 | 349 | 262 | 26 | 11 | 402 | 1057 | 70 |
| General science | 504 | 1 | 16 | 108 | 53 | 2 | 39 | 19 | 0 | 0 | 238 | 47 |
| Solar, geothermal, electrical energy, and storage | 730 | 1 | 24 | 12 | 14 | 8 | 20 | 23 | 23 | 71 | 196 | 27 |
| Magnetic fusion | 383 | 0 | 5 | 2 | 8 | 91 | 21 | 67 | 0 | 2 | 196 | 51 |
| Nuclear | 1165 | 0 | 129 | 1 | 4 | 26 | 39 | 64 | 19 | 20 | 302 | 26 |
| Environment | 227 | 1 | 21 | 11 | 9 | 15 | 12 | 36 | 22 | 2 | 129 | 57 |
| Supporting research | 285 | 12 | 44 | 30 | 20 | 5 | 7 | 41 | 5 | 11 | 175 | 61 |
| Fossil | 822 | 3 | 19 | 3 | 3 | 9 | 7 | 15 | 6 | 24 | 89 | 11 |
| Conservation | 207 | 0 | 27 | 3 | 7 | 1 | 2 | 15 | 6 | 0 | 61 | 29 |
| Other | | 0 | 14 | 4 | 1 | 10 | 34 | 27 | 31 | 7 | 79 | |
| DOE total | 5828 | 18 | 302 | 174 | 121 | 516 | 443 | 331 | 123 | 539 | 2511[a] | 43 |
| Work-for-others | | 2 | 22 | 31 | 24 | 75 | 48 | 81 | 34 | 130 | 447 | |
| Total laboratories | | 20 | 324 | 205 | 145 | 591 | 491 | 412 | 157 | 669 | 2958 | |

[a] Total includes a reduction of $10 million contracted between multiprogram laboratories.

Source: Institutional Plans, individual laboratories.

Table 2.11. DOE budget analysis, obligations for FY 1982
($ in millions)

| | DOE budget | Ames | ANL | BNL | LBL | LLNL | LANL | ORNL | PNL | Sandia | Total laboratories | Laboratories/ DOE (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Defense activities | 1706 | 0 | 2 | 0 | 2 | 377 | 327 | 27 | 13 | 489 | 1237 | 73 |
| General science | 543 | 0 | 20 | 91 | 47 | 2 | 43 | 19 | 0 | 0 | 222 | 41 |
| Solar, geothermal, electrical energy, and storage | 372 | 1 | 6 | 8 | 10 | 2 | 16 | 10 | 16 | 65 | 134 | 36 |
| Magnetic fusion | 454 | 0 | 6 | 1 | 8 | 91 | 21 | 91 | 0 | 3 | 221 | 48 |
| Nuclear | 1140 | 0 | 98 | 1 | 1 | 20 | 41 | 46 | 21 | 23 | 251 | 22 |
| Environment | 173 | 0 | 12 | 11 | 6 | 6 | 10 | 20 | 20 | 1 | 86 | 50 |
| Supporting research | 293 | 13 | 35 | 38 | 20 | 4 | 8 | 44 | 5 | 21 | 188 | 64 |
| Fossil | 417 | 1 | 8 | 2 | 2 | 7 | 5 | 11 | 2 | 15 | 53 | 13 |
| Conservation | 81 | 0 | 13 | 3 | 7 | 0 | 2 | 17 | 9 | 1 | 52 | 64 |
| Other | ——— | 0 | 3 | 4 | 2 | 12 | 36 | 16 | 18 | 3 | 94 | —— |
| DOE total | 5179 | 15 | 204 | 159 | 105 | 520 | 509 | 301 | 104 | 621 | 2526[a] | 49 |
| Work-for-others | | 2 | 28 | 33 | 24 | 72 | 54 | 53 | 33 | 150 | 449 | |
| Total laboratories | | 17 | 232 | 192 | 129 | 592 | 563 | 354 | 137 | 771 | 2965 | |

[a] Total includes a reduction of $13 million contracted between multiprogram laboratories.

Source: DOE Program Offices, Institutional Plans, individual laboratories.

Table 2.12. MPL share of ERDA/DOE budgets

| | FY 1976 | | FY 1977 | | FY 1978 | | FY 1979 | | FY 1980 | | FY 1981 | | FY 1982[a] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $10^6 | %[b] | $10^6 | % | $10^6 | % | $10^6 | % | $10^6 | % | $10^6 | % | $10^6 | % |
| Defense activities | 567 | 67 | 656 | 71 | 745 | 69 | 805 | 69 | 843 | 66 | 1057 | 70 | 1237 | 72 |
| General science | 131 | 53 | 162 | 43 | 173 | 44 | 197 | 46 | 226 | 48 | 238 | 47 | 222 | 41 |
| Solar, geothermal, electrical energy, and storage | 39 | 21 | 73 | 13 | 95 | 13 | 144 | 18 | 173 | 21 | 196 | 27 | 134 | 36 |
| Magnetic fusion | 76 | 46 | 109 | 37 | 153 | 47 | 170 | 48 | 174 | 49 | 196 | 51 | 221 | 48 |
| Nuclear | 193 | 24 | 225 | 19 | 289 | 23 | 293 | 25 | 277 | 23 | 302 | 26 | 251 | 22 |
| Environment | 110 | 54 | 95 | 52 | 123 | 56 | 112 | 51 | 126 | 54 | 129 | 57 | 36 | 50 |
| Supporting research | 108 | 74 | 108 | 69 | 131 | 71 | 146 | 66 | 166 | 66 | 175 | 61 | 188 | 64 |
| Fossil | 25 | 7 | 36 | 7 | 63 | 9 | 61 | 8 | 98 | 11 | 89 | 11 | 53 | 13 |
| Conservation | 15 | 38 | 37 | 37 | 37 | 13 | 56 | 24 | 65 | 22 | 61 | 29 | 52 | 64 |
| Other | 26 | — | 74 | — | 67 | — | 76 | — | 110 | — | 79 | — | 94 | — |
| ERDA/DOE total $[c] and mean share, % | 1286 | 42 | 1568 | 38 | 1867 | 36 | 2042 | 40 | 2247 | 39 | 2511 | 43 | 2526 | 49 |
| Work-for-others | 170 | | 204 | | 240 | | 282 | | 347 | | 447 | | 449 | |
| Total laboratories | 1456 | | 1772 | | 2107 | | 2324 | | 2594 | | 2958 | | 2965 | |

[a] Estimated.

[b] Laboratory share of ERDA/DOE budget for defense, general science, etc.

[c] Does not exactly equal the total of above numbers because of work contracted between laboratories.

Table 2.13. MPL share of ERDA/DOE budgets
(1981 $ based on Department of Commerce price deflator)

| | FY 1976 | | FY 1977 | | FY 1978 | | FY 1979 | | FY 1980 | | FY 1981 | | FY 1982[a] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\$10^6$ | %[b] | $\$10^6$ | % | $\$10^6$ | % | $\$10^6$ | % | $\$10^6$ | % | $\$10^6$ | % | $\$10^6$ | % |
| Defense activities | 831 | 67 | 909 | 71 | 963 | 69 | 958 | 69 | 920 | 66 | 1057 | 70 | 1167 | 73 |
| General science | 192 | 53 | 224 | 43 | 224 | 44 | 235 | 46 | 247 | 48 | 238 | 47 | 209 | 41 |
| Solar, geothermal, electrical energy, and storage | 57 | 21 | 101 | 18 | 123 | 13 | 171 | 18 | 189 | 21 | 196 | 27 | 126 | 36 |
| Magnetic fusion | 111 | 46 | 151 | 37 | 198 | 47 | 202 | 48 | 190 | 49 | 196 | 51 | 208 | 48 |
| Nuclear | 283 | 24 | 312 | 19 | 373 | 23 | 349 | 25 | 302 | 23 | 302 | 26 | 237 | 22 |
| Environment | 161 | 54 | 132 | 52 | 159 | 56 | 133 | 51 | 138 | 54 | 129 | 57 | 81 | 50 |
| Supporting research | 158 | 74 | 150 | 69 | 169 | 71 | 174 | 66 | 181 | 66 | 175 | 61 | 177 | 64 |
| Fossil | 37 | 7 | 50 | 7 | 81 | 9 | 73 | 8 | 107 | 11 | 89 | 11 | 50 | 13 |
| Conservation | 22 | 38 | 51 | 37 | 48 | 13 | 67 | 24 | 71 | 22 | 61 | 29 | 49 | 64 |
| Other | 38 | — | 102 | — | 87 | — | 90 | — | 120 | — | 79 | — | 89 | — |
| ERDA/DOE total $[c] and mean share, % | 1886 | 42 | 2172 | 38 | 2412 | 36 | 2431 | 40 | 2453 | 39 | 2511 | 43 | 2383 | 49 |
| Work-for-others | 249 | | 283 | | 310 | | 336 | | 379 | | 447 | | 424 | |
| Total laboratories | 2135 | | 2455 | | 2722 | | 2767 | | 2832 | | 2958 | | 2807 | |

[a] Estimated.

[b] Laboratory share of ERDA/DOE budget for defense, general science, etc.

[c] Does not exactly equal the total of above numbers because of work contracted between laboratories.

**Table 2.14. Program subcategories**

- Atomic energy defense activities
  - Inertial confinement fusion
  - Naval reactors development
  - Research, development, and testing
  - Verification and control technology

- General science
  - Life sciences/nuclear medicine
  - High energy physics
  - Nuclear physics

- Solar, etc.
  - Solar
  - Geothermal
  - Hydropower
  - Electric energy systems
  - Energy storage systems

- Magnetic fusion

- Nuclear
  - Conventional/breeder reactors
  - Commercial nuclear wastes
  - Interim fuel management
  - Advanced nuclear systems
  - Uranium resource assessment
  - Uranium enrichment R&D

- Environment
  - Overview and assessment
  - Biological/environmental research

- Supporting research
  - Basic energy sciences
  - Technical assessment projects
  - University research support
  - Multiprogram facilities

- Fossil
  - Coal
  - Petroleum
  - Gas

- Conservation
  - Buildings/community systems
  - Transportation
  - Industrial
  - Multisector

### Table 2.15. Full-time staff equivalents from June 1967 to September 1982 for the nine MPLs[a]

| | Ames | ANL | BNL | LBL | LLNL | LANL | ORNL | PNL | Sandia | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| June 30, 1967 | 635 | 5,000 | 3,400 | 2,920 | 5,629 | 4,014 | 4,870 | 2,413 | 8,214 | 37,095 |
| June 30, 1968 | 635 | 5,200 | 3,400 | 2,792 | 5,898 | 4,120 | 5,040 | 2,617 | 8,149 | 37,851 |
| June 30, 1969 | 570 | 5,000 | 3,350 | 2,697 | 5,937 | 4,330 | 4,850 | 2,619 | 8,179 | 37,532 |
| June 30, 1970 | 530 | 4,600 | 3,200 | 2,545 | 5,568 | 4,428 | 4,619 | 2,372 | 7,581 | 35,443 |
| June 30, 1971 | 455 | 4,435 | 2,894 | 2,342 | 5,276 | 4,168 | 4,345 | 842 | 7,291 | 32,048 |
| June 30, 1972 | 410 | 4,356 | 2,542 | 2,342 | 5,538 | 4,183 | 4,143 | 935 | 7,223 | 31,672 |
| June 30, 1973 | 380 | 3,982 | 2,621 | 2,002 | 5,233 | 4,501 | 4,048 | 1,008 | 6,401 | 30,176 |
| June 30, 1974 | 365 | 4,114 | 2,472 | 2,148 | 5,445 | 4,585 | 3,726 | 1,213 | 6,477 | 30,545 |
| September 30, 1975 | 395 | 4,570 | 2,609 | 2,122 | 5,704 | 5,062 | 4,255 | 1,328 | 6,539 | 32,584 |
| September 30, 1976 | 405 | 4,719 | 2,829 | 2,294 | 6,257 | 5,565 | 4,445 | 1,506 | 7,022 | 35,042 |
| September 30, 1977 | 440 | 4,887 | 3,049 | 2,905 | 6,731 | 6,035 | 4,710 | 1,825 | 7,264 | 37,846 |
| September 30, 1978 | 443 | 5,045 | 3,304 | 3,235 | 7,035 | 6,370 | 4,980 | 2,127 | 7,478 | 40,017 |
| September 30, 1979 | 448 | 5,002 | 3,491 | 3,350 | 7,087 | 6,802 | 5,001 | 2,169 | 7,618 | 40,968 |
| September 30, 1980 | 463 | 4,925 | 3,604 | 3,278 | 7,313 | 6,938 | 5,025 | 2,249 | 7,847 | 41,642 |
| September 30, 1981 | 479 | 4,727 | 3,502 | 3,009 | 7,717 | 7,165 | 5,073 | 2,156 | 8,018 | 41,804 |
| September 30, 1982 | 427 | 4,200 | 3,308 | 2,500 | 7,525 | 7,000 | 4,775 | 2,050 | 7,677 | 39,487 |

[a] Estimated. Some of the data consist of FY averages.

Table 2.16. MPL budgets from FY 1976 to FY 1982
($ in millions)

| FY | Ames | ANL | BNL | LBL | LLNL | LANL | ORNL | PNL | Sandia | Total laboratories |
|---|---|---|---|---|---|---|---|---|---|---|
| 1976 | 10 | 178 | 95 | 71 | 265 | 251 | 202 | 74 | 314 | 1456 |
| 1977 | 13 | 201 | 112 | 95 | 306 | 318 | 249 | 88 | 397 | 1772 |
| 1978 | 15 | 226 | 136 | 107 | 378 | 354 | 347 | 117 | 435 | 2107 |
| 1979 | 15 | 257 | 162 | 116 | 447 | 407 | 303 | 122 | 506 | 2324 |
| 1980 | 15 | 286 | 206 | 130 | 469 | 433 | 368 | 136 | 571 | 2594 |
| 1931 | 20 | 324 | 205 | 145 | 591 | 491 | 412 | 157 | 669 | 2958 |
| 1982 | 17 | 232 | 192 | 129 | 592 | 563 | 354 | 137 | 771 | 2965 |

Source: Tables 2.5 to 2.11.

Table 2.17. **MPL budgets from FY 1976 to FY 1982**
**($ in millions)**
**(1981 $ based on Department of Commerce price deflator)**

| FY | Ames | ANL | BNL | LBL | LLNL | LANL | ORNL | PNL | Sandia | Total laboratories |
|---|---|---|---|---|---|---|---|---|---|---|
| 1976 | 15 | 261 | 139 | 104 | 388 | 368 | 296 | 108 | 460 | 2135 |
| 1977 | 18 | 278 | 155 | 132 | 424 | 440 | 345 | 122 | 550 | 2455 |
| 1978 | 19 | 292 | 176 | 138 | 488 | 457 | 448 | 151 | 562 | 2722 |
| 1979 | 18 | 306 | 193 | 138 | 532 | 485 | 361 | 145 | 603 | 2767 |
| 1980 | 16 | 312 | 225 | 142 | 512 | 473 | 402 | 149 | 624 | 2832 |
| 1981 | 20 | 324 | 205 | 145 | 591 | 491 | 412 | 157 | 669 | 2958 |
| 1982 | 16 | 208 | 182 | 122 | 561 | 533 | 335 | 130 | 730 | 2807 |

Source: Tables 2.5 to 2.11.

Table 2.18. MPL roles for DOE programs for FY 1981 and FY 1982

| Program | Nine-laboratory budget ($$10^6$) | | Share of nine-laboratory DOE budget (%) | | Nine-laboratory/DOE in activity (%) | |
|---|---|---|---|---|---|---|
| | FY 1981 | FY 1982 | FY 1981 | FY 1982 | FY 1981 | FY 1982 |
| Atomic energy defense activities | 1057 | 1237 | 42.1 | 49.0 | 70 | 73 |
| Office of Energy Research | | | | | | |
| General science | 238 | 222 | 9.5 | 8.8 | 47 | 41 |
| Magnetic fusion | 196 | 221 | 7.8 | 8.7 | 51 | 48 |
| Supporting research | 175 | 188 | 7.0 | 7.4 | 61 | 64 |
| Total | 609 | 631 | 24.3 | 25.0 | 52 | 49 |
| Energy supply and conservation | | | | | | |
| Solar, geothermal, electrical energy, and storage | 196 | 134 | 7.8 | 5.3 | 27 | 36 |
| Nuclear | 302 | 251 | 12.0 | 9.9 | 26 | 22 |
| Fossil | 89 | 53 | 3.5 | 2.1 | 11 | 13 |
| Conservation | 61 | 52 | 2.4 | 2.1 | 29 | 64 |
| Total | 648 | 490 | 25.8 | 19.4 | 22 | 24 |
| Environment | 129 | 86 | 5.1 | 3.4 | 57 | 50 |

Table 2.19. **MPL work-for-others**
(Current $ in millions)

| Year | ERDA/DOE budget at laboratories | Work-for-others | Total laboratory budgets | Work-for-others in laboratory budgets (%) |
|---|---|---|---|---|
| 1976 | 1286 | 170 | 1456 | 11.7 |
| 1977 | 1568 | 204 | 1772 | 11.5 |
| 1978 | 1867 | 240 | 2107 | 11.4 |
| 1979 | 2042 | 282 | 2324 | 12.1 |
| 1980 | 2247 | 347 | 2594 | 13.4 |
| 1981 | 2511 | 447 | 2958 | 15.1 |
| 1982[a] | 2526 | 449 | 2965 | 15.1 |

[a] Estimated.

Source: Tables 2.5 to 2.11.

**Table 2.20. Performer share of DOE energy R&D budget for FY 1981 ($ in millions)**

| | Nine laboratories (%) | Other DOE (%) | Industry and Other (%) | University (%) | Federal laboratories (%) | Total |
|---|---|---|---|---|---|---|
| General Science | 235.8 (45) | 191.9 (37) | 3.2 ( 1) | 88.5 (17) | 0.9 (<1) | 520.3 |
| Solar, geothermal, electrical energy, and storage | 180.6 (23) | 129.6 (17) | 354.1 (46) | 20.3 ( 3) | 87.3 (11) | 771.7 |
| Fusion | 185.0 (47) | 140.5 (36) | 31.0 ( 8) | 33.9 ( 9) | 3.1 ( 1) | 393.6 |
| Nuclear | 235.3 (20) | 414.7 (35) | 540.7 (45) | 6.6 ( 1) | 1.4 (<1) | 1198.5 |
| Environment | 82.2 (50) | 45.0 (27) | 9.1 ( 5) | 21.7 (13) | 7.5 ( 5) | 165.6 |
| Supporting research | 159.2 (65) | 1.4 ( 1) | 19.9 ( 8) | 60.5 (25) | 4.6 ( 2) | 245.7 |
| Fossil | 76.8 (10) | 67.7 ( 8) | 608.6 (76) | 35.5 ( 4) | 14.5 ( 2) | 803.2 |
| Conservation | 55.7 (25) | 3.5 ( 2) | 88.6 (39) | 4.4 ( 2) | 74.5 (33) | 226.6 |
| Total | 1210.6 (28) | 994.3 (23) | 1655.2 (38) | 271.4 ( 6) | 193.8 ( 4) | 4325.2 |

Source: DOE Program Office Data.

**Table 2.21. Performer share of DOE energy R&D budget for FY 1982 ($ in millions)[a]**

| | Nine laboratories (%) | Other DOE (%) | Industry and Other (%) | University (%) | Federal laboratories (%) | Total |
|---|---|---|---|---|---|---|
| General Science | 223.0 (41) | 212.3 (39) | 15.4 ( 3) | 93.2 (17) | 1.9 (<1) | 545.8 |
| Solar, geothermal, electrical energy, and storage | 102.5 (30) | 40.6 (12) | 140.5 (41) | 17.7 ( 5) | 44.9 (13) | 346.1 |
| Fusion | 220.8 (49) | 148.6 (33) | 40.6 ( 9) | 41.1 ( 9) | 2.7 ( 1) | 453.8 |
| Nuclear | 241.1 (20) | 424.6 (36) | 506.5 (43) | 4.7 (<1) | 3.2 (<1) | 1180.0 |
| Environment | 75.8 (46) | 42.3 (26) | 17.8 (11) | 24.2 (15) | 4.8 ( 3) | 165.0 |
| Supporting Research | 173.5 (68) | 1.1 (<1) | 13.2 ( 5) | 64.3 (25) | 4.6 ( 2) | 256.7 |
| Fossil | 48.2 (12) | 60.2 (14) | 271.3 (65) | 18.8 ( 4) | 19.8 ( 5) | 418.2 |
| Conservation | 52.4 (31) | 2.7 ( 1) | 58.8 (35) | 1.9 ( 1) | 54.7 (32) | 170.4 |
| Total | 1137.3 (32) | 932.4 (26) | 1064.1 (30) | 265.9 ( 8) | 136.6 ( 4) | 3536.0 |

[a] Estimated.
Source: DOE Program Office Data.

Table 2.22 displays the federal agencies performing energy R&D with DOE funding. Although a large number of agencies are involved, the National Aeronautics and Space Administration (NASA) dominates this sector. Furthermore, most of NASA's funding comes from Solar and Conservation programs.

Figure 2.1 presents a different perspective on the MPLs (i.e., an analysis of the phase of R&D carried out by the respective laboratories). These data are derived from the Institutional Plans. Three laboratories are highly oriented toward basic research (i.e., Ames Laboratory, Brookhaven National Laboratory, Lawrence Berkeley Laboratory); they are heavily staffed by scientific personnel. Three laboratories have balanced activities ranging from basic research to engineering development (i.e, Argonne National Laboratory, Los Alamos National Laboratory, and Oak Ridge National Laboratory). Lawrence Livermore National Laboratory is oriented toward applied research and advanced development. Finally, Pacific Northwest Laboratory and Sandia do a considerable amount of engineering development; Sandia is the only laboratory employing more engineers than scientists.

Table 2.22. Agencies performing energy R&D with DOE funding

| Agency | Relative Funding Level[a] | | | | | | |
|---|---|---|---|---|---|---|---|
| | Solar, geothermal, etc. | Fusion | Nuclear | Environment | Supporting research | Fossil | Conservation |
| National Aeronautics and Space Administration | *b* | *e* | *d* | *d* | *e* | *c* | *b* |
| Defense | *c* | *d* | *d* | *d* | *d* | *c* | *c* |
| National Science Foundation | *e* | *e* | *e* | *c* | *c* | *e* | *e* |
| Interior | *d* | *e* | *c* | *e* | *e* | *c* | *e* |
| | | | | | | | |
| Commerce | *c* | *e* | *d* | *d* | *e* | *e* | *d* |
| Agriculture | *c* | *e* | *d* | *d* | *d* | *d* | *d* |
| Tennessee Valley Authority | *d* | *e* | *d* | *e* | *e* | *c* | *d* |
| Environmental Protection Agency | *e* | *e* | *e* | *d* | *e* | *c* | *d* |
| | | | | | | | |
| State | *d* | *e* | *e* | *d* | *e* | *d* | *e* |
| Housing and Urban Development | *e* | *e* | *e* | *e* | *e* | *e* | *d* |
| Transportation | *e* | *e* | *e* | *e* | *e* | *e* | *d* |

[a] Based upon obligations in FY 1981 and FY 1982 (through June 1982).
[b] Over $100 million.
[c] Between $10 million and $100 million.
[d] Between $0.5 million and $10 million.
[e] Below $0.5 million.

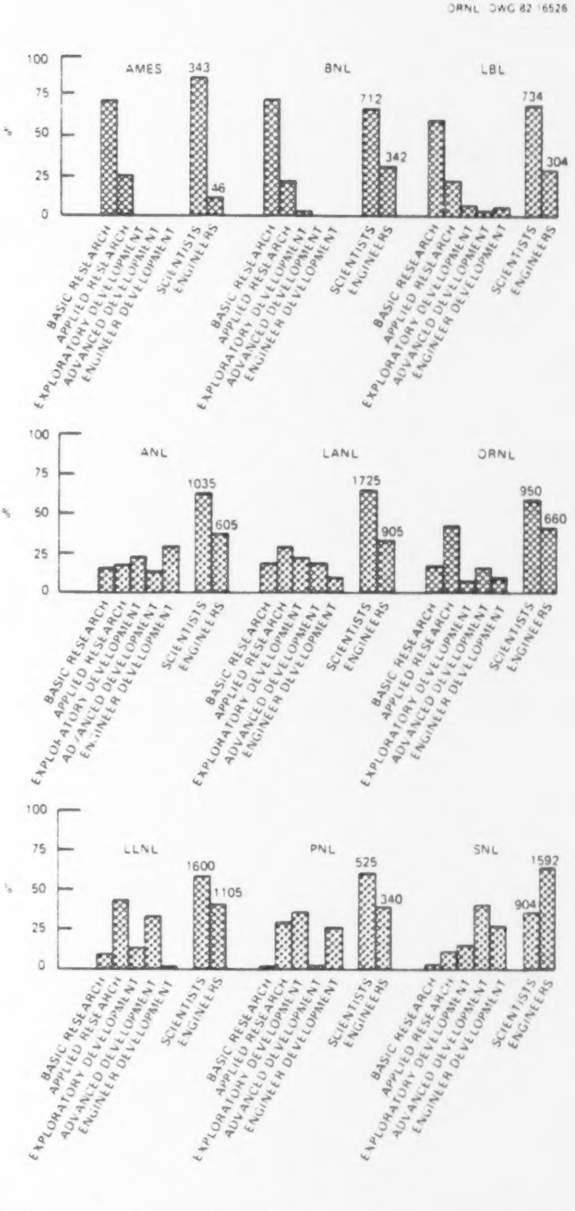

Fig. 2.1. Phase of R&D at the DOE MPLs for energy R&D (excluding defense activities). The number of scientists and engineers are also shown.

# 3. EXAMPLES OF NATIONAL LABORATORY USE IN FOREIGN COUNTRIES

E. L. Preston and C. D. West

## 3.1 Introduction

The objective of this brief study, which was requested by the Department of Energy's (DOE's) Energy Research Advisory Board, is to help define possible future roles of United States national laboratories on the basis of recent experiences of foreign laboratories.

The authors have studied how certain foreign governments use their scientific establishments to conduct research and development (R&D) and to help formulate national R&D policy. There are major differences in the way that R&D is conducted and supported in different countries. These national differences may or may not relate to how countries utilize their national laboratories. The work included brief case studies of foreign laboratories; important parameters of the studies were laboratory scope, methods of funding, relationships with industry, and access of the private sector to the laboratories.

Most of the information for this study was collected over a two-month period (December 1981 through February 1982) from numerous sources. Telephone conversations were held, and visits made, with scientific attachés in embassies, and staff of the National Science Foundation (NSF), the Department of State, the United Nations, the Office of Technology Assessment, and DOE. Staff of Oak Ridge National Laboratory (ORNL) who have visited and worked in the laboratories selected for study, and researchers visiting ORNL from foreign countries, were consulted. Both manual and computerized data-base searches have been performed. A listing of these information sources is given at the end of this section.

From the study of other countries and their federal R&D effort (in particular, the applied R&D efforts for civilian applications), a number of major differences among them, and between their systems and the United States system, emerge fairly clearly.

- Large changes in a laboratory's work areas and sponsorship can be made successfully, (United Kingdom, Sweden, and the Netherlands)* apparently without significantly reducing the quality and value of its research work (United Kingdom).

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*A country's name absent from the list of examples does not necessarily mean that a similar point does not apply to that country, but only that our brief study has not investigated the question; it should be noted that our information about the Japanese experiences is especially incomplete.

- These changes take a long time (United Kingdom, Sweden, and the Netherlands) but can be accomplished without growth and without the need to expand into new scientific disciplines (United Kingdom).
- A national laboratory can be useful to government beyond its original mission (France, Sweden, and United Kingdom).
- A unique product or service developed and provided by a government facility can be successfully "hived off" as a separate, free-standing entity or company (France, Sweden, and United Kingdom).
- Industry and government can work together to determine fruitful lines of research that are economically important to the nation and to allocate government funding for that research to the organization best suited to carry it out (United Kingdom).
- Government can delegate detailed technical judgements, leading to distribution of the overall budget established by government, to active scientists and scientific administrators (France and United Kingdom).
- Interactions with industry can be encouraged through government laboratories and agencies designated by government to work in areas of interest to a particular industrial sector (France).
- In the civilian field, government R&D can be served through large laboratories that are single, rather than multipurpose (France and Japan).
- Government R&D needs can also be met by a multitude of small laboratories rather than by a few large ones (the Netherlands and Japan).
- Government laboratories can work directly for industry (France, United Kingdom, the Netherlands, and Sweden), or in collaboration with industry (France, Japan, the Netherlands, Sweden, and United Kingdom) without insuperable legal or institutional problems.
- Government laboratories are capable of producing technical innovations, products, or research services that industry values highly enough to pay for (France, the Netherlands, Sweden, and United Kingdom).
- Government laboratories are capable of training, or attracting, staff who can transfer technology for use in industry (France, Sweden, and United Kingdom).
- Industry can be involved in government research projects by the assignment of substantial numbers of scientists from (and employed by) industry to work at government laboratories (Japan and France).

The manner in which foreign countries organize their national R&D programs has many similarities to and many differences from our R&D structure in the United States. The establishment and use of national laboratories is only one way in which governments carry out R&D missions. The United Kingdom, France, the Netherlands, Sweden, and Japan are just a few of the developed countries which do make use of national laboratories. These foreign laboratories are usually funded from several sources (agencies, ministries, boards, industries, etc.) just as our U.S. multipurpose laboratories are supported. In addition to national laboratories, many countries have established electric-power research organizations, energy research centers, solar energy centers, and numerous research advisory groups. Some nuclear laboratories have been transformed into energy R&D facilities. With the emergence of these new and renovated R&D organizations in the different countries, overlap and duplication of effort, and competition for government funding occurred just as we have seen in this country.

This section will discuss briefly some of the lessons that have been learned in other countries by governments seeking to increase the value of federal R&D, its relevance to civilian national needs, and its usefulness to industry. Of course, *some of the policies and actions undertaken in other countries could not be applied in the United States (even if overseas experience has proved their effectiveness) because they would conflict with strong national traditions;* examples of such traditions include the avoidance of all competition between government and industry for markets, and the desire to make rather detailed technical decisions about programs in the political community rather than in the scientific community. Nevertheless, *much thinking about the organization of scientific effort has been done in other countries, and the lessons learned from this thinking are valuable* in considering alternative ways of using the United States national laboratories.

## 3.2 Experiences of Foreign Laboratories

We continue to be in the midst of the technological revolution and, despite worldwide economic depression and inflation, countries are striving to increase the percentage of gross domestic product (GDP) that is earmarked for R&D.

The most startling recent example of a national R&D goal is that of France, where the new government intends (economy permitting, presumably) to raise the national R&D expenditure from 1.8 to 2.5% of GDP in the next three years. The outcome of the new French policies and the changes arising from them will not be known for many years; however, their establishment is proof that the new government does not feel that the existing system, which will be described later, adequately meets what they perceive as the national need for R&D.

*Many laboratories are becoming much more market-oriented.* This is especially true of Harwell in the United Kingdom and Studsvik in Sweden, both of whom have compensated for steep declines in the national budgets for nuclear-related R&D in part by seeking funds for other kinds of work directly from private industry.

Bureaucracies in all countries make the operation and financing of government research facilities a cumbersome and difficult process. Most facilities have to submit budgets on an annual basis; however, Sweden's Studsvik Laboratory had a three-year budget cycle until recently, and France is proposing a five-year budget commitment. *Multiyear budgets provide far more stability and continuity to research programs and allow increases and decreases in funding to be dealt with in a more orderly fashion.* The Swedish government-owned company, Studsvik Energiteknik AB, was able to cope with a decrease from 50 to 30% government financial support from about 1975-1980 because they had enough lead time to reorganize, shift personnel, and seek nongovernment customers. No reductions in the work force were necessary. As with the operation of any business, a goal that is well defined and has top management support and a realistic schedule, has a much better probability of being achieved than if one or more of these criteria are missing. Studsvik knew three years in advance of their pending budget cuts, and they had a staff of only 900 to support. The new French government has recognized the diseconomies of annual budgetary upheavals for R&D by proposing a law that will fix, in broad terms, the funding available for various areas of research: over a five-year period, the process will lay down the rates of increase of the budgets and personnel in government research and of government support for industrial R&D.

The purpose of the study was to learn something of how foreign countries conduct R&D and how they utilize their large laboratory facilities and to answer the question: how are their laboratories different from ours, and how have they brought about changes in research and financial support? Because the study was aimed particularly at seeking answers relating to national laboratory use, we have concentrated on applied, not basic, research organizations and funding. *It must be emphasized that this was not a comparative study;* rather, we sought simply to discover examples of different ways in which national laboratories, or their equivalents, have been used to fulfill the R&D needs perceived by their governments and, to a lesser extent, other ways in which governments accomplish R&D. The small amount of effort available (three person-months) necessarily limited the coverage that could be given to each country and topic. We are well aware that many, perhaps most, of the national differences in R&D policy and execution result from their different social and political structures: it was no part of the study objective to investigate these structures or to relate them to the operations of the laboratories studied. Not all the lessons learned by other countries would be directly applicable to the United States. Justin Bloom, Scientific Attache at the U.S. Embassy in London, recently wrote, "There are such radical differences in the U.S. and the U.K. that it will be extremely difficult to extrapolate from the British experience to find new approaches for the U.S. national laboratories" (Department of State Incoming Telegram, London 01526, January 1982). Nevertheless, we feel that a knowledge of some, at least, of the options that have been devised and used in other countries will be helpful to policy makers and advisers considering new ways to use our national laboratories.

A study of one or more laboratories or organizations in five countries has been made:

- United Kingdom — Harwell Laboratory and the Department of Industry's Requirements Boards
- France — Centre d'Etudes Nucléaires de Saclay (CEN-Saclay) and Bureau de Recherches Geologique et Minieres
- Netherlands — Toegepast-Natuurwetenschappelijk Onderzoek (TNO) — Central Organization for Applied Scientific Research in the Netherlands
- Sweden — Studsvik Energiteknik AB
- Japan — Japan Atomic Energy Research Institute, Tokai Research Establishment (JAERI-Tokai)

The authors believe that the laboratories and organizations selected are different from each other and from United States national laboratories in significant ways (Table 3.1). For example, the TNO (Netherlands) is a large organization, approximately the same size as most United States national laboratories (5000 staff), but it is composed of at least 50 distinct institutes and centers in over 20 different locations and carries out a substantial amount of work for industry. CEN-Saclay (France), on the other hand, is a multidisciplinary research laboratory which is funded by the French Atomic Energy Commission [Commissariat à l'Energie Atomique (CEA)]; it illustrates some of the ways in which CEA brings the results of R&D into the economy, although it is similar in some other respects to the United States national laboratories. Despite similarities between the characteristics of the various national laboratories shown in Table 3.1, a great variety exists in the approaches they have taken to the problems and tasks involved.

The laboratories and organizations that have been selected for study represent several different characters of research; for example, the JAERI-Tokai facility is devoted entirely to nuclear research, whereas Harwell and Studsvik were both previously nuclear institutions that have recently made a dramatic shift, either in the areas of research undertaken or the sponsors they serve, and have concurrently initiated both national and international marketing efforts.

This ORNL study focused especially, but not exclusively, on the Harwell Laboratory for a number of reasons: (1) the authors have relatively easy access to information and its interpretation because one of the authors, C. D. West, was previously on the scientific and planning staff of Harwell (1965-1977) and because the ORNL Associate Laboratory Director for Advanced Energy Systems, Murray W. Rosenthal, made a visit to Harwell as recently as October 1981 to discuss the nature and extent

**Table 3.1. Characteristics of foreign national laboratories under consideration**

| Laboratory | Staff | Multipurpose | Emphasizes marketing | Recent shift in funding | Extensive interaction with industry |
|---|---|---|---|---|---|
| UKAEA-Harwell[a] | 4300 | Y[b] | Y | Y | Y |
| Studsvik | 1100 | Y | Y | Y | Y |
| TNO | 5000 | Y | Y | Y | Y |
| JAERI-Tokai | 1500 | N[c,d] | N | N | Y |
| CEN-Saclay | 5800 | N[c,d] | N | N | Y |

[a] United Kingdom Atomic Energy Authority-Harwell.

[b] Y = yes

[c] N = no

[d] These laboratories have the bulk of their applied research directed toward a single field.

Sources: Commissariat à l'Energie Atomique. *Saclay Nuclear Research Center & the National Institute of Nuclear Sciences and Technologies.* Editions Brun, Paris; Europa Publications Limited. 1981. *Europa Year Book 1981. A World Survey.* Vol I. Gale Research Company, Detroit, Mich.; Japan Atomic Energy Research Institute. 1979. *JAERI.* Japan Atomic Energy Research Institute. Tokyo; Japan Atomic Energy Research Institute. 1980. *Annual Report and Accounts 1978/80.* Japan Atomic Energy Research Institute. Tokyo; Studsvik. *Organization. Fields of Activity. Studsvik.* Studsvik Energiteknik AB. Nyköping; Studsvik. *Årsberättelse 1980/81.* Studsvik Energiteknik AB. Nyköping; United Kingdom Atomic Energy Authority. 1980. *Harwell Research Laboratory of the United Kingdom Atomic Energy Authority.* United Kingdom Atomic Energy Authority.

of work for private industry and non-United Kingdom Atomic Energy Authority (UKAEA) sponsors; (2) Harwell has been primarily a nuclear research institution just as DOE's national laboratories are; and (3) the ORNL authors believe that from a similar starting point, Harwell has moved farther away in mode of operation from the U.S. idea of national laboratories than have any of the other laboratories being studied.

The remaining material of this section which, because of severe time constraints, is based on brief and necessarily incomplete studies, gives the information that has been collected about several foreign laboratories. Several gaps exist in the information presented. Caution should be exercised in the interpretation of budget figures and percentages of support supplied by industry. In some cases industries that support R&D at government laboratories are nationalized industries; such industries could be considered either as governmental or private concerns, according to the degree to which they are free to make purchasing decisions on purely commercial, as opposed to political, grounds.

### 3.2.1 United Kingdom

The Harwell Laboratory of UKAEA is similar to the nonweapons DOE national laboratories in that it is large, multidisciplinary, and was originally created with a research mission related to the development of civilian nuclear energy. It differs from the U.S. laboratories in that it does not do much life sciences work, responsibility for health effects of nuclear energy having been vested from the beginning in a statutory body completely separate from UKAEA. Nevertheless, it represents perhaps the single largest pool of scientific and technical manpower in Britain. More detailed information about the structure, size, and activities of Harwell is given in Appendix A.

By the mid-1960s it was clear that Harwell's task was largely done and that remaining research needs in nuclear energy could be satisfied by a much smaller laboratory. As an alternative to a drastic size reduction, the UKAEA proposed, and the government eventually accepted, that Harwell should attempt to diversify its work but not its range of scientific disciplines (Science and Technology Act 1965). The government of the day was socialist, newly elected (1964) on a platform that made much of the need to apply "the white heat of technology" to Britain's many problems. It is perhaps not too surprising that the support of such an administration was forthcoming for an experiment in applying a government nuclear laboratory to broader national and industrial needs. However, in 1970, long before Harwell's diversification program had grown significantly (Fig. A.1), a new government, conservative and committed to a policy of nonintervention by government, was in power; after an initial period of mistrust, the new government allowed the experiment to continue.

The percentage of all R&D funding provided directly by the government is not much higher in Britain (55%) than it is in the United States (50%) (National Research Council 1982), but the British government perhaps makes stronger efforts, through devices such as Harwell and the Requirements Boards, to make its civilian applied R&D relevant to industrial as well as national needs. In this respect, it is now clear that Harwell's diversification has been, by most measures, successfully implemented to the benefit of both the Laboratory and the nation. The benefit to the nation is fairly easy to quantify, since the diversified work of Harwell is generally paid for by a sponsor who has determined that Harwell is a better place than all domestic and, in many cases, foreign, alternatives to get a particular piece of research done. The major benefits to the Laboratory, presumably, are that it is still in existence, still able to attract staff, and still enjoys a good technical reputation; indeed, its reputation has broadened by the wider range of contacts made in the course of its new, diversified research work.

The general perception (promoted by the Laboratory itself) is that Harwell has changed from an organization supported entirely by government to one supported largely by private industry. However, this is not true, and if it were, little would probably be learned from it that might be copied by the United States government. What has really happened is that over the past 15 years Harwell has changed from an organization devoted almost entirely to, and sponsored only by, the government's nuclear energy program to one devoted increasingly to other kinds of work on behalf of the government; at the present time actual funds from British private industry amount to only about 10% of the Laboratory's support, and overseas funding amounts to another 5%. Table 3.2 illustrates this, although the figures should be interpreted with caution because some of the entities that are government-owned in Britain (such as the coal industry) would be private industry in the United States.

In addition to work funded directly by a single company, Harwell undertakes programs funded by industrial consortia and joint government-industry programs. Patents arising from these programs and from government-funded work may be licensed on an exclusive or near-exclusive basis in the normal commercial way. The ability to grant such a license is, and has been since the start of the commercial program, recognized

**Table 3.2. Major sources of funding for Harwell Laboratory (1979/1980)**

| Source | Funds (%) |
|---|---|
| Atomic Energy vote[a] | 42 |
| Government agencies | 22 |
| Requirements Boards[b] | 9 |
| Other United Kingdom government[c] | 15 |
| Private industry (United Kingdom) | 7 |
| Overseas | 5 |

[a] The "vote" is the funding directly and explicitly set aside by Parliament for atomic energy development, which is in the hands of a statutory body — UKAEA, the parent body of the Harwell Laboratory. Prior to the diversification, almost all of Harwell's funding was "vote" money; the diversification away from a single-purpose laboratory directed solely to atomic energy research is indicated by the much-reduced importance to Harwell of the "vote."

[b] Government R&D funding whose allocation is decided by panels of industrialists, academics, and civil servants (see p. 43 and Appendix B for further details).

[c] Including nationalized industries.

by the Harwell staff as a key factor in facilitating the transfer of technology to an industrial organization, justifying the investment by a company in learning, applying, and marketing a new technology that can give a commercial advantage over other companies in the same market. In recent years, the government has allowed Harwell to use at least some of the royalty income from these licenses to fund further R&D instead of requiring its return to the Treasury where it became part of the government's general funds, not earmarked for any particular organization or purpose. The amount involved is only about 1% of Harwell's budget, but it is an important incentive to the Laboratory and provides a small amount of extra freedom of technical choice to the management.

The Laboratory has found no difficulty in, and the government has placed no obstacles in the way of, ensuring the necessary confidentiality for industrial collaboration. Administratively, the system is almost identical to the existing arrangements for national security information, with appropriate changes in nomenclature.

A major lesson learned from Harwell, perhaps, is that once a large laboratory has been assembled, it can be useful to government in fields that extend far beyond its original mission; this is evidenced by the range of funding sources shown in Table 3.2 — less than half of Harwell's funds are now used in its original mission. In addition, this shift has been accomplished while maintaining high technical standards and some world class facilities; British and foreign industrialists recognize this so well that they choose Harwell over all alternatives, including their own laboratories, for some tasks.

Besides the particular example of Harwell, there are at least two other important ways in which Britain has organized its government R&D resources differently from the United States. The first is the Requirements Boards, which were referred to previously. These Boards are composed mainly of industrialists representing various fields of commerce (computer and electronics, textiles, etc.) and control $100 million of the government funds for civilian research in these areas: this figure represents about one-third of all the research funds available to the United Kingdom's Department of Industry. The scheme has some similarities to proposals that were made by the Department of Commerce in recent years but were never carried out because funds were not made available. The Requirements Boards decide whether there is an industrial need for the research (generally, generic research) proposed to them and allocate the available funds accordingly; the proposals may come from any competent source, and the allocation of some $10 million per year (out of a total of $100 million) to Harwell is a measure both of Harwell's success in identifying needed research and of industry's high opinion of Harwell's capabilities and value. More details of the Requirements Boards are given in Appendix B, but it should be added here that they are not regarded as a perfect solution by all; the view has been expressed that the industrial members of the Boards tend to allocate the funds toward the solution of current problems rather than, as might be more in the national interest, toward the creation of future opportunities, technologies, and markets.

The second major difference is in the incorporation of active scientists (from the most senior operating levels of government laboratories, universities, and industry) into government decision making. This is usually through statutory bodies or through high-level committees to the civil service; there is little tradition in Britain of detailed technical decision making or budget allocation by Parliament. The difference, and its results, are hard to quantify but easy to illustrate; thus, the present director of the Harwell Laboratory is also a member of the UKAEA board (which has, in any case, less detailed overview by elected bodies than had the AEC), and the members of the Science Research Councils (which allocate government funds for basic research, mostly to universities) are usually active scientists or scientific administrators from academia. Evidently, the British government takes a more robust view of the capabilities of its advisors to overcome conflict-of-interest problems than is the case for the United States.

Another important example of the United Kingdom's approach to the use of federal investments is afforded by Amersham International, a company formerly owned by the government but sold to private shareholders in 1982. It began as a government laboratory producing radioisotopes and radiochemicals and researching their applications. It was the sole or major British source of the isotopes used in research, medicine, and testing. No private United Kingdom industrial company in the same business existed, yet it is clearly in the national interest to have a reliable source of these products. The organization, named the RadioChemical Centre at the time, was turned into a limited company whose shares were at first owned entirely by UKAEA and was charged with operating in a commercial manner and supplying products for which there was a market need. The experiment was successful: sales grew and so did the revenue from overseas customers. The government had found a way to meet a national need without forsaking responsiveness to market needs — a responsiveness that is usually lacking in bureaucracies — and to make a profit for the taxpayers at the same time. The existence of foreign competition has undoubtedly sharpened Amersham's planning and marketing activities. When Amersham finally went public, the stock offering was heavily oversubscribed. Also, it seems that even prior to its "privatization," as the transfer to private stockholders was inelegantly called, the company was expected to buy its irradiation services wherever they were most economical, whether that was in a government laboratory (Harwell) or elsewhere.

### 3.2.2 France

Although currently undergoing great change, the French system is significantly different from those in Britain and the United States. A new Ministry of Research and Technology (MRT) has been created in the last year: the Minister is Jean-Pierre Chevenement, who is one of the state ministers, the senior cabinet members of the French government. His goal is to spend 2.5% of the French GDP on R&D by 1985; the R&D expenditure in the late 1970s was 1.8% of GDP. Chevenement has acquired an enormous amount of authority over R&D because he was given the lead role in defining projects and specifying budgets for all laboratories and research facilities even though they may be part of other ministries such as the Ministries of Industry,* Sea, and Education: MRT does not, however, control defense research. Chevenement is convinced that increased research spending is a way out of economic crisis because it provides a sound base for technology industries. He believes that it is better to spend money on research as an investment in the future than on unemployment benefits. The large government laboratories, such as Saclay, are multidisciplinary but tend to be more nearly single purpose or more specialized in their field of interest than are our national laboratories. They are not the primary focus of industry/government cooperation, although some smaller laboratories and government companies are established at the major centers to provide access to government research facilities and expertise for industry; in some respects they are like the user facilities at national laboratories but set up for the sole purpose of involving industry.

A measure of the importance attached by the new government to technology transfer is the size of the proposed budget increases for agencies whose work is related to that area: for example, a 76% increase for the $250 million budget of Agence Nationale de Valorisation (ANVAR), whose task it is to convert research in university and government laboratories into productive industrial innovations, and an 80% increase in the funding for the dissemination of scientific information.

As in Britain, one important mechanism for harnessing government investment and research capability to commercial needs, at the appropriate time, is the spin-off company. Isotope production, electronic communications technology, and certain solar energy technologies are examples of work, initially carried out by CEA, now in the hands of government-owned companies subject to most of the usual rules for private companies.

Created in 1945, CEA has been reorganized and redirected several times. It is now authorized to work in nonnuclear technology, to engage in commercial activities and to form subsidiary and joint companies; however, the law specifies that CEA must avoid direct competition with private enterprise. Its most recent reorganization, in June 1982, has created a new sector of the organization responsible for industrial applications of both the nuclear and nonnuclear work. It is, of course, too soon to know how, and how effectively, this will operate.

There are several subsidiary corporations, with CEA as sole or joint stockholder, for commercializing the results of government-sponsored research. For example, in 1975 Compagnie General des Matieres Nucleares (COGEMA) was formed, by decree, to take charge of industrial and commercial activities relating to nuclear materials. Perhaps a more surprising example is Compagnie Internationale de Services en Informatique (CISI), Europe's largest data processing company, which was formed in 1972 from the Data Processing Department of the CEA and which has acquired several subsidiaries and minority holdings both in France and overseas. Its major center of operation and management and 300 of its 800 staff are located at the Saclay Laboratory.

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*Chevenement has since been given direct responsibility for the Ministry of Industry as well.

Opened in 1952, the Saclay Laboratory of the CEA now has a staff of 5800; in addition, approximately 2000 outside personnel from industrial firms and their research organizations work at Saclay. Approximately 40% of the effort at Saclay is devoted to basic research, with more than 85% of the applied work being in various nuclear safety, nuclear applications, and radioisotope programs. Saclay does carry out work for outside organizations, on repayment, although this is not a large source of revenue. Another means of interaction with industry and other government organizations is the joint project. A recent example is the joint "deep-sea polymetallic nodules" project. These nodules are rich in several metals, including manganese, nickel, cobalt, and copper, that are commercially valuable and are important to the French economy. The organizations involved jointly in this project are CEA; Centre National pour l'Exploitation des Oceans (CNEXO), the government organization responsible for exploitation of the oceans; Le Nickel, a company of the Rothschild group; and Minemet. CNEXO retrieves the nodules, and CEA develops and runs the basic chemical processing; any patents resulting from this work would be shared by all of the parties involved.

Another way of linking government research capabilities to industrial needs is through single-mission government agencies or *Bureaux* with responsibility not for research in general but for particular sectors of industry. Such agencies tend to be responsible only for applied research and do not generally undertake basic research. As an example, the Bureau de Recherches Geologique et Minieres (BRGM) maintains certain specialized research facilities and capabilities. They work, with government money, on tasks believed to be important to the nation as a whole, but in recent years they have begun to work extensively for industry as well. In the last 20 years, the percentage of BRGM's funding coming directly from the federal government has fallen from 95% to about 50%. Other sources are industrially funded work and joint ventures with industry, foreign governments, French and foreign municipal governments, and the income from the Bureau's own mines! BRGM projects for the government include assessment of water and mineral resources and of geological hazards. Work with industry includes exploration for, and development of, oil and mineral resources. Government funding for BRGM was previously supplied by the Ministry of Industry, but is now the responsibility of the MRT.

Like the British government, the French government has chosen to involve working scientists in technical decision making to a much greater extent than the United States. At the policy making level, there is the Advisory Committee for Scientific and Technical Research (CCRST) whose 16 members are "chosen purely on the merits of their work," (Allen 1974) leading to the name "Committee of Wise Men." The CCRST advises on all matters submitted to the Inter-Ministerial Committee (chaired by the Prime Minister) for Scientific and Technical Research and offers advice to the Secretary of State for Research. At a lower level, more than 40 panels of working scientists make recommendations, which are nearly always accepted, on funding, programs, and personnel matters within the basic science research budget distributed by the Centre National de la Recherche Scientifique (CNRS), which controls most of France's basic science. Finally, the national laboratory directors have freedom to move funds, after they have been granted, between different research areas (but not between different account categories, such as operating and capital).

Despite the efforts of the *Bureaux* and the industrial activities of the CEA laboratories, the new government of France evidently does not feel that enough is being done to commercialize the results of government research and is increasing the emphasis on, and funding for, work devoted to the commercialization of government R&D results.

### 3.2.3 The Netherlands

The Dutch government organization TNO controls a large number (35) of rather small institutes working on all aspects of applied research: the conduct of pure research is the responsibility of a separate organization, Zuiverwettenschappelijk Onderzoek (ZWO). The total staff of TNO number some 5000, only 800 of whom are engaged in defense research. The annual budget of TNO is about $200 million, of which roughly 10% is spent on energy problems.

The TNO laboratories can, and do, carry out research directly for industry, on repayment, and their facilities can also be made available to industry. Since the midsixties, a slow but significant shift in TNO's funding sources has occurred, with the proportion of industrial funding increasing from 25% to more than 40% (Table 3.3).

**Table 3.3. Funding sources for TNO**

| | Funds | | |
|---|---|---|---|
| Year | Government (%) | Contract (%) | Ratio of government to private funds |
| 1965 | 75 | 25 | 3.0 |
| 1973 | 69 | 31 | 2.2 |
| 1981 | 57 | 43 | 1.3 |

Although TNO is a Dutch government organization it, like Harwell, carries out research for both foreign and domestic industrial sponsors. The results of the contract work are confidential, but the research implemented under the government subsidy is published in the open literature in the usual way.

Besides research, the Institutes carry out more or less routine testing, chemical analyses, etc., and provide training services. Each Institute has an advisory committee, which includes industrialists, that helps to decide upon the work (not including the confidential work, presumably) carried out.

Like most other countries, the Dutch government fixes the research budget before the start of the fiscal year. Control over the research program topics is exercised, within the overall budget fixed in Parliament, by the individual ministry responsible. The TNO budget has been fairly constant, after allowance for inflation, over the last several years, rising slowly in the late 1970s and declining somewhat since then (see Appendix A).

### 3.2.4 Sweden

The laboratory studied in Sweden is Studsvik Energiteknik AB, a government laboratory organized as a company. With 1100 employees at Studsvik and overseas, it is smaller than the other organizations studied. The Board of the company includes politicians of different political parties. Originally its mission was solely as a nuclear energy research laboratory, called AB Atomenergie. By the early 1970s the work area had expanded to include other energy sources, in particular solar energy. In 1978 the name change to Energiteknik reflected the expansion that had taken place in the Laboratory's nonnuclear work. Nevertheless, slightly more than half of the funding involved in Studsvik's activities is still for nuclear technology.

In the mid-1970's the company was forced to reorganize its efforts and concentrate more on marketing its skills to nongovernment sponsors when funding from the National Swedish Board for Technical Development (STU) was cut from 50 to 30% of the Laboratory's funding. This transition, of which the Laboratory was given three years' warning, has been accomplished without reductions in staff by increasing sales (the word used by a representative of Studsvik) to industrial and overseas customers. Among the side effects of this commercialization of Studsvik is a noticeable reluctance by Laboratory management to publish or discuss the kind of basic data — budget, staffing levels, funding sources, and areas of work — that is normally available from civilian government organizations. Nevertheless, some information on Studsvik's funding and manpower history will be found in Appendix A.

Studsvik, perhaps in imitation of Harwell's earlier response to similar problems, adopted a matrix form of management structure to allow the utilization of various disciplines in quick response to customer needs. However, it was remarked that on occasion it had become necessary to employ staff outside their particular field of expertise, which caused some concern about the maintenance of quality in the research performed.

Each of the two major technical divisions (Nuclear Technology and Energy Technology) has a marketing group, and the Laboratory operates as nearly as possible like a private company. Besides setting up wholly-owned subsidiary companies to sell products and services, such as the Alnar Instrument Company in America, Energiteknik is also a minority shareholder in a number of joint subsidiaries: for example, C-E/Studsvik, Incorporated was formed in the United States in association with Combustion Engineering to market Studsvik's small-scale simulators for the training of reactor operators. These subsidiary companies must necessarily be very responsive to market needs, if they are to survive, and in doing so they are transferring Studsvik's technology into the hands of users. It may be objected that in many cases the users — for example, the American nuclear industry — are benefitting from work carried out by a Swedish government organization on behalf of the Swedish people and Swedish industry. But the work is paid for, and money is returned to the Swedish economy that otherwise would not be.

As indicated earlier, Studsvik's government budget, although renewed yearly, was planned by the government on a three-year basis; those plans were shared with Laboratory management. This was a crucial factor in allowing Studsvik to respond to the decline in STU funding without losing a valuable government resource.

### 3.2.5 Japan

At least until recently, government has played a less active role in scientific and technical research in Japan than in other major advanced nations. According to one source, the federal government and private industry each fund about 50% of the United States research effort, while in Japan the government:industry ratio is about 30:70. Japan's R&D expenditures as a percentage of the gross national product (GNP) (1.93% in 1978) are somewhat lower than those of the United States, United Kingdom, or West Germany; however, when defense budgets are eliminated, Japan's expenditures are slightly higher than those in the United Kingdom and the United States, but lower than in West Germany. Japan employs about as many research personnel as Germany, France, and United Kingdom combined and has increased the national research effort markedly in the last decade or so (Table 3.4).

**Table 3.4. National research efforts**

| | Researchers (in thousands) | | Increase |
|---|---|---|---|
| | Late 1960s | Late 1970s | (%) |
| Japan | 158 | 272 | +72 |
| United States | 550 | 571 | + 4 |
| West Germany | 72 | 94 | +31 |
| France | 55 | 62 | +13 |
| United Kingdom | 57 | 78 | +37 |

Source: "Japanese Technology Today." October 1980. *Sci. Am.* 243(4):J6.

Most sources identify three major sectors of Japanese research: corporation and industry laboratories, government experimental research laboratories, and university research. In 1975 the industrial share was 66%, including such public corporations as the Japan National Railway (JNR) and Nippon Telephone and Telegraph (NTT). Universities averaged about 19% of the research, while the research institutes accounted for the remaining 15%. Although many government agencies oversee various kinds of research, the largest projects are associated with three: the Ministry of Education, which supervises university research; the Ministry of Trade and Industry's (MITI's) Agency of Industrial Science and Technology; and the Science and Technology Agency (STA). (See Appendix A, Fig. A.9 for a breakdown of the structure of government research.) Japan has numerous research laboratories and institutes, many of them affiliated with universities. However, most of their "national laboratories" are much more research specific and much smaller than are United States multipurpose national laboratories (e.g., the National Research Laboratory of Metrology with just over 250 people and the National Chemical Laboratory for Industry which employs about 450).

While most of these laboratories are civil service bodies, a few, including JAERI, have been established as corporations, described variously as "public corporations," "Semi-Government Research Organizations," and "Special Status Corporations." Although the relationship between these research institutes and the government seems to be complex and difficult to understand by outsiders, it seems safe to say that although they receive most of their funding from the government, they are set up to be independent entities, not mere auxiliaries to the government. Legally, these research institutes or corporations are not subject to quite the same restrictions as those with civil service employees.

If we exclude the NTT, which is considered to be part of the industrial sector, the largest government-supported research institutes are those associated with nuclear energy; JAERI, and the Power Reactor and Nuclear Fuel Development Corporation (PNC), both under the auspices of the STA. In 1975 nuclear energy research accounted for 26.5% of the total national science budget of 85.6 billion yen (about 286-million 1975 dollars).

In 1956 JAERI was established to hasten the research, development, and utilization of atomic energy. It was originally conceived of as being the center of both basic and applied research. However, the commercialization of nuclear power became increasingly sensitive in the 1960s and while business and industry were eager to promote the commercialization of light-water reactors, the scientific community tended to be more cautious, preferring to focus on basic research. Thus, in the early 1960s severe labor disputes developed at JAERI. Eventually it was decided that JAERI was not an appropriate agency for promoting technology, and in 1967 the PNC was established with the aim of contributing to the development and utilization of nuclear power. Today JAERI concentrates on research in nuclear safety; multipurpose, very high-temperature gas-cooled reactors; nuclear fusion; radiation applications fundamental reactor physics and engineering. Currently it has four established branches: Tokai, Oarai, Tokasaki, and Osaka; however, Tokai uses about 1500 of its approximately 2400 staff. Also, a large tokamak is under construction at Naka near Tokai. This project is currently under Tokai administration and constitutes a significant portion of the JAERI-Tokai budget (possibly as much as 30%), although it may eventually become a separate branch. About one-third of Tokai's staff is administrative support, with scientists and engineers totaling about 1000, and the laboratory houses several research reactors. JAERI-Tokai programs, including fusion, fission, health physics, waste management, and reactor physics and safety, involve substantial basic research. Unlike the other branches, the head of JAERI-Tokai is automatically a member of the JAERI's Board of Directors, reporting directly to the president. The JAERI organization chart is shown in Fig. A.10.

The JAERI budget is a national budget rather than a government contract, and the budget procedure illustrates JAERI's somewhat independent status. JAERI initiates the funding procedure for the coming fiscal year. Scientists at JAERI submit research proposals to the Institute's Board of Directors, and the directors coordinate the proposals and submit a unified proposal to STA. The STA discusses with JAERI their proposals and assesses them, probably making changes. It then submits the proposal to the Ministry of Finance who coordinates the budget with other projects under its jurisdiction and it may change the budget drastically. Eventually, the Ministry of Finance submits the budget to the government who then submits it to Congress. Congress nearly always approves the entire government budget intact. Occasionally, a few minor changes are made to non-R&D segments of the budgets, but not usually to the R&D budget. One reason for this may be Japan's parliamentary system, which requires a closer agreement between the government and the Congress than does the United States presidential system.

Japan's fiscal year runs from April through March. In a normal year the budget procedure begins in November and by late December or early January the government's proposal has been completed. In January the budget goes to Congress for its approval by the end of March. JAERI's FY 1982 budget is 91,000 million yen compared with ~13,000 million yen in 1972, an average increase of about 11% over the Japanese inflation rate during the period. (See Fig. A.7 in Appendix A.) Much of the increase, however, has taken place in fusion energy.

Most of the people interviewed agree that JAERI works closely with industry, although budget figures indicate that only about 1 to 2% of JAERI's funding are provided by industry. Companies such as Hitachi, Toshiba, and Mitsubishi assign staff to JAERI on a "temporary" basis for periods ranging from two to eight years. These temporary staff then are able to take advantage of the latest research techniques and equipment which they share with their employers when they return to their home companies. In addition, several sources have indicated that JAERI subcontracts "substantial amounts" of work to private industry, partly because of their limited staff. Also, according to one source, these companies often offer to do work free and in return, retain the rights to the data.

The patent policy is focused more toward protecting Japanese companies from competitors than encouraging individual Japanese companies to compete with each other. One source said that there is an effort to avoid competitive bidding on these patents and to balance the distribution of technology among companies. JAERI holds a large number of patents (180 applications were filed in 1979); many of them are made available to Japanese industry to use, either free or for payment. JAERI, like all government laboratories, makes its patents available to industry through a central government agency (Research Development Corporation of Japan) which has responsibility for such licensing. The revenues from the patents accrue to the government.

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#### Embassies

Hiroyoshi Kurihara, Science Counselor; Embassy of Japan; 600 Watergate Building, Suite 900; Washinigton, DC 20008; (202) 234-2266, ext. 205.

Hiroto Ishida, Science Counselor; Embassy of Japan; 600 Watergate Building, Suite 900; Washington, DC 20008; (202) 234-2266.

Jan Vasbinder, Scientific Attaché; Royal Netherlands Embassy; 4200 Linnean Avenue, NW; Washington, DC 20008; (202) 966-0707.

Leif Ericson, Attaché; Science and Technology; Swedish Embassy; 600 New Hampshire Avenue, NW, Suite 1200; Washington, DC 20037; (202) 298-3562.

Louis-Francois Pau, Scientific Attaché; French Scientific Mission; 2129 Wyoming Avenue, NW; Washington, DC 20008.

Jacques Bodell, Scientific Attaché; French Scientific Mission; 2011 I Street, NW, 5th Floor; Washington, DC; (202) 659-3550.

Yoshitoka Tomii; Embassy of Japan; 600 Watergate Building, Suite 900; Washington, DC 20008; (202) 234-2266

John Gaunt, Atomic Energy Liaison Officer; British Embassy; 3100 Massachusetts Avenue, NW; Washington, DC 20008; (202) 462-1340.

Justin Bloom, Science Counselor; Embassy of the United States of America; 24 Grosvenor Square; London W1A1AE, England; 44-1-499-9000, ext. 2238 or 2127 or Box 40 FPO; New York, NY 09510.

Abraham Freedman, Science Attaché; United States Embassy; Ave. Gabriel 8e(E); Paris, France.

Bertrand Barre, Scientific Attaché; Nuclear Energy French Scientific Mission; 1920 N Street; Washington, DC 20036; (202) 785-1833.

#### Government Agencies

##### National Science Foundation

Henryk Uznanski; U.S./Scandinavia Cooperative Science Programs; International Programs Division; National Science Foundation; 1800 G Street, NW (Madison Bank Building), Rm. 1201; Washington, DC 20550; FTS 357-7554.

**Government Agencies** (continued)

## National Science Foundation

Stephen R. Mosier, Program Manager; U.S.-France Cooperative Science Programs; International Programs Division; National Science Foundation; 1800 G Street, NW (Madison Bank Building), Rm. 1201; Washington, DC 20550; FTS 357-7554.

J. Hamilton Andrews, Special Assistant; Science Resources Studies Division; National Science Foundation; 2000 L Street, NW; Washington, DC 20550; FTS 634-4640.

Lionel C. Bischoff, Head; Editorial and Inquiries Unit; Science Resources Studies Division; National Science Foundation; 2000 L Street, NW; Washington, DC 20550; FTS 634-4622.

## Department of State

Dan Clemmer, Reference Librarian; Foreign Affairs Information Management Center/Library; Department of State; 21st and C Streets; Washington, DC 20520; FTS 632-3609.

Pamela Burton; Office of Energy Technology Cooperation; Department of State; 21st and C Streets; Washington, DC 20520; FTS 632-3939.

## U.S. Department of Energy

Kay McKeogh, Director; Energy Producing and Consuming Nations; Office of International Affairs; U.S. Department of Energy; Forrestal Building; 1000 Independence Avenue, SW; Washington, DC 20585; FTS 252-6770.

Moustafa Soliman; Office of International R&D Cooperation; U.S. Department of Energy; Forrestal Building, Rm. 7G090; 1000 Independence Avenue, SW; Washington, DC 20585; FTS 252-6140.

Billy Hill, Representative; U.S. Department of Energy; Embassy of the United States of America; Tokyo, Japan.

## United Nations

Vera Gathright, Information Assistant; United Nations Library; Washington, DC.

**Government Agencies** (continued)

**Office of Technology Assessment**

John P. Andelin, Jr., Assistant Director; Office of Technology Assessment; (202) 226-2253.

**Universities and Laboratories**

Herbert Holloman; Center for Policy Alternatives; Massachusetts Institute of Technology; Cambridge, MA; (617) 253-1661 and 253-1604.

Nicholas Ashford; Center for Policy Alternatives; Massachusetts Institute of Technology; Cambridge, MA; (617) 253-1664.

Eileen Callum, Documents Librarian; Center for Policy Alternatives; Massachusetts Institute of Technology; Cambridge, MA; (617-253-1659.

Oak Ridge National Laboratory; Post Office Box X; Oak Ridge, TN 37830; M. W. Rosenthal, L. A. Berry, W. C. Koehler, S. Datz, F. Plasil, M. Olszewski, M. A. Karnitz, R. H. Chapman, and P. N. Haubenreich.

Christer Hughert, Information Director; Studsvik Energiteknik AB; Nyköping, Sweden; 011-46-155-80000.

Alexander Houtzeel, Former Director of U.S. TNO Office (Now President, Organization for Industrial Research, 240 Bear Hill Road, Waltham, MA 02154); (617) 890-4030.

Walter Zegveld, Director; Policy Research and Information Group; Schoemakerstraat 97; 2628 VK Delft; P.O. Box 215 - 2600 AE Delft; The Netherlands; 310015-569330.

S. Shimamoto, Chief; Superconducting Magnet Laboratory; Division of Thermonuclear Fusion Research; Japan Atomic Energy Research Institute; Tokai-Mura, Naka-Gun; Ibaraki-Ken; 319-11 Japan; 02928 (2) 5440.

Charles J. Madic (visiting scientist from Centre d' Etudes Nucleaires de Fontennayaux-Roses, France); Chemistry Division; Oak Ridge National Laboratory; P.O. Box X; Oak Ridge, TN 37830; (615) 574-4940.

Michel Bouchi-Lamontagne, press Attaché; Bureau de Recherches Geologique et Minieres; Scientific and Technical Center; BP G009; 45 Orleans 2; France.

Richard P. Suttmeier, Associate Professor of Government; Kirner Johnson Bldg. Rm 217C; Hamilton College; Clinton, NY; (315) 859-4361.

Masashi Iizumi, Chief; Neutron Scattering Group; Japan Atomic Energy Research Institute; Tokai-mura, Naka-gun, Ibaraki-ken, Japan.

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# 4. DOMESTIC MODELS FOR NATIONAL LABORATORY UTILIZATION*

T. J. Wilbanks

This section presents an overview of the policies and procedures of federal agencies other than the Department of Energy (DOE) in utilizing their laboratories. Because surveying these agencies and their laboratories in a truly comprehensive way would have taken longer than the schedule for the study allowed, it is based instead on the available literature, contributions from selected consultants and other knowledgeable observers of federal research and development (R&D) institutions, and a small number of site visits. To gain a broader perspective, the information about the practices of federal agencies was supplemented by published material on the uses of their own R&D laboratories by private industry.

For the purposes of this study, no consistent definition of multiprogram laboratories (MPLs) was attempted as a basis for making comparisons with DOE laboratories. Clearly, the hundreds of federal R&D laboratories† vary widely in mission, size, organizational history, and management style; and their sponsoring agencies differ considerably in how they see the purposes of their laboratories. Some "models" appear to be more relevant for the study than others, and more attention was paid to these cases of relatively large multipurpose institutions [e.g., National Aeronautics and Space Administration (NASA), Jet Propulsion Laboratory (JPL), Department of Commerce (DOC), National Bureau of Standards (NBS), and Department of Defense (DOD)/RAND]. But the study included a search for interesting ideas and options in centers ranging from small civil service laboratories to large, diverse ones operated outside the civil service.

## 4.1 An Overview of the Issues

To bound the territory and focus the discussion, this section will address five issues, selected because of their importance to DOE and the likelihood that the practices of other agencies would suggest some useful options: (1) general ownership and management arrangements, together with examples of changes in them; (2) breadth vs focus in defining the purposes of laboratories; (3) relationships of laboratories with sponsoring organizations, especially in planning laboratory R&D programs and determining allocations of funds; (4) laboratory relationships with external institutions, particularly the private sector;

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†Because of problems of classification, counts of the number of federal laboratories and research centers differ, but they have ranged as high as 759.

and (5), where applicable, agency experience during times of retrenchment. The following parts of the section will very briefly describe each of these issues, identify some options, and provide some illustrative information about agency practices and apparent pros and cons of the options.

## 4.2 General Ownership and Management Arrangements

The DOE MPLs are government-owned but contractor-operated (GOCO), and this arrangement appears to work very well. It has, in fact, been copied by other agencies when they see a need to create new laboratory capabilities (Teich, Lambright, and Flynn 1975). From time to time, however, questions are raised about the current system. For example, does DOE have more GOCO laboratories than it needs? If so, what are the alternatives, and how hard is it to make a change? Why should not the laboratories be government-operated, civil service institutions like the Energy Technology Centers? Or, conversely, why should not the connections with the government be loosened, retaining a special relationship in a few specific areas but leaving it to the laboratory to compete in the open market in other areas (similar to, say, RAND, MITRE, or Aerospace)? These are questions that have been confronted by other agencies over the years, and their viewpoints and experience may be of interest to DOE.

This section will (1) identify the major ownership/management options and summarize the conventional wisdom about their pros and cons, (2) note the viewpoints of other agencies about the appropriate management formula as it relates to the purpose of a laboratory, and (3) examine some cases where ownership/management arrangements have been changed.

### 4.2.1 Ownership/management options

The principal options being used by federal agencies are (from least to most flexible) (1) government-owned, government-operated (GOGO); (2) GOCO, and (3) federal contract research centers (FCRCs), not government-owned but formally dedicated in whole or in part to meeting the needs of a federal agency [in a sense, contractor-owned, contractor-operated (COCO)].* Still more flexible is the status of a for-profit or nonprofit firm as a "prime contractor" for a federal agency, giving it a special relationship with the agency for particular purposes for a specified period of time; such a contractor is normally selected through a competitive procurement process.

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*In some cases, "hybrid" arrangements have evolved, combining aspects of government ownership and industry or university ownership.

GOGO laboratories are operated as branches of a federal agency, and their employees are civil servants. Many of these facilities are small and narrowly mission focused, analogous to DOE's Energy Technology Centers, but several are relatively large and diverse, such as NBS and the Naval Research Laboratory (NRL). Aside from providing stability and continuity by simply continuing arrangements that have evolved historically, the main advantages of this approach are that (1) it is administratively straightforward: the rules of the game are well understood; (2) in-house laboratories can be expected to share the sense of mission of their agency and to be especially responsive to its needs; and (3) in some cases it has obviously delivered excellent work. Its main disadvantages are (1) problems with the recruitment and retention of key personnel because of the rigidity of civil service personnel and salary structures, (2) the vulnerability of institutions to government actions that are inconsistent with their capabilities (e.g., mandated programs or missions), and (3) the requirement for the government itself to staff and administer every part of the operation, which tends to bureaucratize a laboratory's organization and adds to government employment needs (and, it can be argued, involves the government directly in work that could be done by others). Although some people certainly disagree, a number of reports have argued that, because of these problems, many in-house government laboratories have a relatively weak record (DOD 1970), and some of the strongest ones are finding it difficult to maintain their capabilities (Teich 1978). This perception appears to be part of the reason for the strong government interest since World War II in management alternatives to GOGO.

4.2.1.1 **Conventional GOCO.** In its simplest form, the GOCO approach calls for a fixed-term but renewable contract between a federal agency and a contractor, under which the contractor administers an R&D operation in government-owned facilities for an annual fee. Laboratory staff are considered employees of the contractor, but they work in buildings and use items of equipment that are property of the government. The contractor may be a university, a firm, or a consortium of parties, but it gets no proprietary benefits from laboratory research or facilities (whatever is available to the contractor is also available to other parties on the same terms). Its role is almost entirely administrative. Non-DOE examples include Lincoln Laboratory (DOD) and the National Center for Atmospheric Research (NSF).

4.2.1.2 **Variations on the theme.** The following are examples of variations.

*Special conditions in the prime contracts.* The prime contract between DOE and the operator of a laboratory may define special conditions appropriate to the characteristics of that particular contractor and the intended role of that particular laboratory. Some of the conditions can affect contractor-agency and contractor-laboratory relationships; for example, DOE's contracts with the University of California specify five areas of "mutuality," apparently giving the university greater flexibility than other contractors in interacting with DOE and with its laboratories (Hiestand and Florsheim 1969).

*A "consolidated laboratory."* The Battelle Northwest/Pacific Northwest Laboratory (PNL) shows that a contractor can be intermeshed with a national laboratory so that, under special terms, proprietary research by the contractor can be carried out in government facilities and a substantial portion of the DOE effort can be housed in private facilities (Appendix D).

*Other hybrid arrangements.* When laboratories are co-located with universities, other kinds of overlaps may develop as well, such as the close university ties of the Joint Institute for Laboratory Astrophysics in Boulder, Colorado, and the considerable number of LBL staff members who are also tenured faculty members of the University of California. Another example of a hybrid arrangement is JPL, which is the extension of an R&D contract between NASA and the California Institute of Technology rather than an operating contract (i.e., California Institute of Technology delivers R&D to NASA, not administrative services).

4.2.1.3 **Other possible variations.** One can also imagine a case where a national laboratory might operate itself for DOE. If an FCRC such as RAND can incorporate itself to provide laboratory-type assistance to a federal agency on a not-for-profit basis,* working out of private facilities, there seems to be no reason why such activities could not be operated in government-owned facilities. All that would be required, presumably, would be for the laboratory to (1) incorporate itself for the purpose of entering into a contract with DOE and (2) make arrangements to provide for its own administrative services, either by adding necessary staff or contracting with others to provide them. Orlans reports, for example, that in 1947, when the contract to operate Oak Ridge National Laboratory (ORNL) was up in the air, Commissioner Strauss suggested that laboratory scientists "themselves form a corporation to serve as the contractor" (Orlans adds: "...an interesting idea that came to naught") (Orlans 1972).

These possibilities illustrate the attractiveness of the GOCO idea. Although the approach is not widely used outside DOE, it offers the advantages of (1) flexibility in designing a management arrangement to suit particular needs; (2) direct federal control, combined with the staffing and management flexibility more characteristic of industrial firms and universities; (3) less red tape in purchasing and other R&D-related actions; (4) a degree of scientific credibility often difficult to attain for a purely in-house organization; (5) convenience in freeing the federal government from the responsibility for administrative details; and (6) consistency with a philosophy that intramural government activities should be minimized. The various manifestations of the approach are so diverse that it is difficult to generalize about the disadvantages, but they may include (1) a lesser commitment to an agency mission, especially in a competitive environment for institutional support; (2) some perceived conflicts of interest, especially if the operator is a hardware manufacturer; and (3) some degree of bafflement in society at large about the nature and functioning of national laboratories.

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*RAND operates as "a nonstock, nonprofit, tax-exempt corporation performing research under contracts and grants from government agencies and private nonprofit institutions concerned with public problems."

Other laboratory-like research institutions operate without government ownership of facilities but with all or part of their effort dedicated to meeting the needs of a federal agency. These "FCRCs" include such multipurpose nonprofit firms as RAND, MITRE, and Aerospace, working in support of the U.S. Air Force (USAF), as well as such scientific research facilities as the Stanford Linear Accelerator Center. Their responsibilities and rules of the game are defined by contracts with the sponsoring agency, just as with a GOCO laboratory. Since the FCRC arrangement in practice is very similar to a GOCO arrangement (many of the individual differences probably reflect variations in the viewpoints of sponsoring agencies rather than fundamental differences between management approaches), its advantages and disadvantages are also similar. Compared with a GOCO arrangement, the FCRC approach may offer somewhat greater flexibility, autonomy, and credibility to an R&D institution. As possible disadvantages, it may lead to bigger questions about the relevance of the institution to agency needs, and the various connections of members of an FCRC board of directors have sometimes raised questions about conflicts of interest.

The most flexible arrangement is one in which a for-profit or not-for-profit firm is awarded the status of a "prime contractor" for a federal agency, giving it a special relationship with the agency for particular purposes for a specified period of time. Although operating a GOCO laboratory is one example of this, a firm may also be selected itself to play a laboratory-like R&D role (generally not a multipurpose one), especially a program management or program support function. For an agency need that is not envisioned as long term, this offers a kind of built-in "sunset clause," but it brings with it less assurance that the contractor will focus its attention on more general missions and needs of the agency.

In summary, the MPLs in existence across the country involve so many unique characteristics and circumstances that it is exceedingly difficult to evaluate the effects of a general management approach on laboratory effectiveness (Office of Technology Assessment 1980). As mentioned above, it can be argued that an FCRC approach gives an institution more independence from the concerns of a single agency than a GOGO approach, but on the other hand, it can be argued that a GOGO laboratory is more secure in its relationship to its sponsoring agency than an FCRC. It is probably true that scientific quality is harder to maintain under a civil service personnel system, but such institutions as NBS, NRL, National Institutes of Health (NIH), and United States Geological Survey (USGS) show that it is not impossible. Most likely, the key ingredients to laboratory success lie in factors other than management approach alone: agency understanding of how science works, laboratory tradition and leadership, and others.

### 4.2.2 Choosing the right management formula

It is seldom clear that the particular management framework in place between an agency and a laboratory is the result of a careful study of alternatives, but in most cases, the agency feels strongly that its current formula is the only one appropriate, given the purpose of the research institution. For instance, USAF from the outset wanted RAND to have a considerable amount of independence, combined with a continuing commitment to meeting USAF needs. From their point of view, the value of RAND as an advisor depends on this combination; neither a GOGO formula nor a prime contractor relationship would meet the need. In fact, they even questioned whether an FCRC located in the Washington, D.C. area could possibly maintain enough of a long-range perspective to serve their purposes; the choice of a California location was related directly to the functions of RAND as they were viewed by USAF (Smith 1966). There are other examples of a relatively careful study of management alternatives, such as the National Science Foundation's (NSF's) establishment of national research centers in the late 1950s (opting for the GOCO approach, at least partly because NSF's charter forbids GOGOs). But the large majority of the federal research centers are the way they are for historical reasons, and the most common question has been (rather than which formula would be ideal) whether the benefits of a change are worth the costs.

### 4.2.3 Changes in management arrangements

Most laboratories and FCRCs have been relatively stable in their management relationships, but there have been some instances in the past 20 years in which the arrangements have been changed. The most sweeping set of changes resulted from a series of studies during the early 1970s of USAF contracting practices. As a result of these studies, the USAF decided that it had been relying too heavily on in-house research and that, consequently, it might have become too ingrown and isolated. To correct this situation, it made several changes in its R&D support system: (1) clarifying the special roles of RAND, MITRE, and Aerospace for USAF and authorizing them to create organizational units separate from their activities meeting USAF needs; (2) "delisting" one FCRC, Analytical Services (ANSER), which in principle became a conventional contractor (the transition was eased by a large five-year sole source contract, intended both to help the firm develop other capabilities and sources of support and to give USAF time to learn about its other options for meeting needs being satisfied by ANSER); (3) redirecting some of its laboratories, such as the USAF Cambridge Research Laboratories (converted from basic research to an "exploratory development" institution, with one division transferred to another center); and (4) closing one laboratory, the Aerospace Research Laboratory at Wright-Patterson (40% of the staff transferred to other USAF laboratories, 20% shifted to universities with USAF research support, and 30% lost their jobs).

The other major episode of changes in management arrangements was the widespread shift to some sort of independent status in the late

1960s of university-based centers doing classified work (Orlans 1972). Further changes worth noting are:

1. The conversion of Fort Detrick, Maryland, from a GOGO center for biological warfare research to an GOCO NIH center, first for cancer research and later for research on recombinant DNA.

2. The metamorphosis of NASA's Electronics Research Center into the Department of Transportation's Transportation Systems Center.

3. The transfer of the management contract for the Center for Naval Analysis from Franklin Institute to the University of Rochester (1967).

4. Environmental Protection Agency's (EPA's) efforts to consolidate its highly fragmented laboratory system without relocating very many of its facilities or activities.

Besides converting from one kind of management approach to another, federal research centers have been known to beget other institutions, at least some of which are managed differently from the parent. The most prolific of these "seed" institutions has been the RAND Corporation, from which the Systems Development Corporation (SDC) and ANSER developed as separate FCRCs (Smith 1966). Other organizations founded by former RAND employees include the Planning Research Corporation and the Hudson Institute (Smith 1966). SDC later converted to a profit-making status (Coddington and Milliken 1970) and now operates as a conventional consulting firm.

### 4.3 Breadth vs Focus

An abiding issue for all federal agencies maintaining research laboratories has been defining the purposes of their laboratories. Most of these research institutions began with a clear-cut mission, either to get something specific done or to maintain, use, and make available large facilities that were better placed under the auspices of the federal government than controlled by some other kind of agency or firm. As national needs (and science and technology) have changed, many of the laboratories have shifted in their purposes, becoming centers of excellence in ways that depart in some respects from their original mission. This process has been studied extensively, but few of the basic questions have really been settled. For instance, how does one distinguish between laboratory diversification as responsiveness to changing national needs and diversification as a less noble expedient for laboratory survival or growth? Does the latter impulse help in meeting the need for responsiveness, or does it just lead to inappropriate competition with other research institutions? Does diversification undercut a sense of mission? Does focus undercut responsiveness to new needs? Other agencies beside DOE have had to deal with these questions, and their practices are worth reviewing.

To cast some light on this issue, the following section will consider (1) the pros and cons of breadth and focus, as they are viewed by agencies other than DOE and by the literature on national laboratory roles; (2) alternative ways of articulating the purpose of a laboratory, along with ways of keeping it on track; and (3) policies regarding "work-for-others" — R&D for agencies and other sponsors besides the parent agency — as they relate to the purpose of a laboratory.*

### 4.3.1 Pros and cons of focus

"How to bring the laboratories into a greater congruence with national interests" (Office of Technology Assessment 1980) is a continuing challenge for the federal government. At present, the federal laboratories and research centers differ widely in statements of their missions, from specific wording included in federal legislation [whose apparent clarity may be misleading (Teich 1978)] to missions that must be inferred from what people do. Too often, the situation is murky, even though a clear and consistent sense of its mission is a key to the organizational health of a laboratory.† The lack of such a sense is especially likely in agencies whose own missions or organizational structures are subject to frequent change and in laboratories whose work is relatively applied.

But long-term "national interests" are not quite the same thing as short-term "agency interests." The general conception of MPLs is that they are:

> Centers of initiative that are capable of perceiving, formulating and exploring significant research problems with considerable autonomy relative to the sponsoring agency. Because of their independence and breadth of talent, these laboratories are able...to serve missions broader than those assigned by their parent agencies (Office of Technology Assessment 1980).

This suggests a possible difference between missions assigned to an MPL by its sponsoring agency, many of which involve considerable focus on current agency concerns, and some broader missions of the laboratory as a national resource — and a more general resource for the agency itself.

Two examples are discussed at length in the literature. One is the need for laboratories to play roles in early warning and quick response, both of which require a base of expertise that may be broader than specific missions of current interest: for instance, in order to provide the early warnings about important science and technology developments, an institution must monitor the frontiers of research in diverse fields

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*This is an issue in industry as well as national laboratories (Rosenbloom and Kantrow 1982).

†Industry observers have noted that their approaches to planning R&D are often hard to apply to public R&D programs because (at least in energy) the mission of the agency and the objectives of national policy are not clearly enough defined (Jeffries 1982).

(Office of Technology Assessment 1980). The other, centrally important in agencies concerned with R&D, is the need for laboratories to serve as an agency's main source of technical strength — its advisors, evaluators, and "smart buyers" (Teich, Lambright, and Flynn 1975). In addition, the literature on R&D in industry stresses that one reason corporate laboratories pay off is that they combine strong disciplinary expertise with breadth. They can take advantage of "the fact that basic research in one area can often influence an area that superficially seems unrelated" (Jeffries 1982) [see the current discussion of proposed legislative constraints on Bell Laboratories (Dickson 1982)].

In any event, two aspects of the mission of a laboratory seem to transcend the question of breadth vs focus. First, a critical function of a national laboratory is its "continuing, primary commitment to the study of one agency's problems" (Orlans 1972). This is one of the characteristics which distinguishes a public-sector laboratory from other kinds of R&D institutions. Second, a national laboratory is expected to maintain "a strong sense of identification with national purposes" (Office of Technology Assessment 1980). This also differentiates a laboratory from, say, a private firm (which identifies most strongly with the firm's goals) or a university (which is concerned primarily with the goals of academic disciplines and the learning process).

Within these general guidelines, however, there is still room for considerable debate about breadth vs focus. The principal alternatives are (1) breadth as a basic objective, (2) focus as a basic objective, (3) breadth and focus as opposite ends on a continuum, with the laboratory prepared to shift in either direction according to national needs for science and technology in a particular period; and (4) focusing, at least to some degree, the role of a laboratory for the sponsoring agency but allowing it to make its own decisions about diversifying to meet the needs of other sponsors.

**4.3.1.1 Breadth.** One option is to assign a laboratory a mission of addressing broad, complex national science/technology issues in an integrative way, which requires diversified capabilities. It has been argued that no other institution in American society plays this role — and that someone must (Rose 1974). Such DOE laboratories as ORNL and Argonne National Laboratory (ANL) have traditionally seen this as part of their distinctive contribution, although this self-image appears to have arisen from within the institutions themselves rather than from the conscious decisions by the sponsoring agency.

**4.3.1.2 Focus.** Another alternative is to focus a laboratory on a specific mission, such as the early focus of many DOE laboratories on helping to develop a nuclear power industry — a common practice for the smaller in-house government laboratories and research centers. Focus may be interpreted in a variety of ways (see Sect. 4.3.2).

**4.3.1.3 Flexibility.** A further possibility is to allow for a certain amount of flexibility in determining the roles and missions of laboratories, expecting that national needs will vary over time. In some periods, a laboratory might shift its resources toward a focus on a single, discrete national problem; in others, it might shift in the direction of a broader treatment of a complex national issue. In practice, this has been the experience of most DOE laboratories.

4.3.1.4 **Latitude.** Finally, an agency can define a relatively well-focused role for a laboratory but permit it to diversify into other roles if they meet the needs of other sponsors. For instance, USAF sees RAND as its center for studies and analysis, while MITRE and Aerospace are centers for systems engineering. But these FCRCs are allowed to develop other roles if they identify a need. Similarly, Jet Propulsion Laboratory has the prime NASA responsibility for planetary and other deep-space missions, but it is generally free to diversify elsewhere, subject only to finding support for activities it considers suitable.

Generally, it appears that a clearly-defined focus for a laboratory makes it responsive, and probably more aggressive, in that particular area, but such a laboratory is relatively slow to respond to changes in external conditions, either scientific or policy related, or to unconventional, complex, or crosscutting research problems. A more diversified laboratory appears to anticipate and respond better to changes in conditions, to develop and maintain first-rate capabilities, and to prepare itself to meet future R&D needs (Teich and Lambright 1975; Rose 1974); however, it may be less responsive in meeting current needs, and its place in the panoply of research institutions in the United States may be less well understood. Our present system seems to include some of both, together with a fair amount of flexibility in adapting roles and missions to changing national needs.

Aside from the efforts by USAF and EPA to reevaluate their R&D support structures, mentioned earlier, perhaps the most relevant example of a reconsideration of laboratory missions is NASA's undertaking in the mid-1970s. Contemplating an assemblage of research centers which had diversified considerably since the mid-1960s, NASA decided after a major study in 1975-1976 to make specific role and mission assignments for each center, changing the roles of eight of the eleven institutions. As it turned out, in many cases these assignments became counterproductive straitjackets for the centers, and NASA ended up issuing instructions to those centers to loosen the interpretations of their mission statements (Office of Technology Assessment 1980). But the process was valuable to NASA in thinking through its needs and problems, even if some capabilities were lost as a result.

Clearly, as national needs change, a mismatch is likely to arise between needs and laboratory capabilities. At any given time there are almost certain to be at least a few functions of laboratories that are unnecessary and/or inappropriate. According to the literature, however, dealing with these problems by mission assignments is a tricky business:

> Defining a mission requires an expert and delicate sense of balance: a mission must be sufficiently specific to include some things and exclude others; at the same time, it must also

> be flexible enough not to stifle creativity, become too constraining, or prevent the use of a lab's capability for a purpose that departs from a 'legalistic' interpretation of the mission statement (Office of Technology Assessment 1980).

There seem to be two principal strategies for resolving this complexity (neither excluding the other). The first is to involve laboratory technical people in a cooperative (or at least interactive) process leading to the definition of the institution's mission. Laboratory morale and vitality are likely to suffer otherwise. The second is to recognize that redeployment of a laboratory by external fiat is usually disruptive. Unless the institution is no longer needed or the new mission is radically different, redeployment can often be handled from within, as a survival-oriented organization seeks to be useful. It can be argued that entrepreneurial instincts are an effective decentralized mechanism for keeping laboratories responsive (sponsoring agencies share the responsibility of channeling this energy in appropriate ways).

### 4.3.2 Alternative conceptions of focus

The purpose of a laboratory can be defined in many different ways, a few of them combining some of the benefits of focus with some of the benefits of breadth. For instance, all of the DOD research centers are focused in one way or another, but the branches of the military service differ in their choice of focus: USAF on disciplines (from basic research through nonsystem advanced development), the Navy on platforms (e.g., aircraft, submarines, or surface ships — multidisciplinary, relatively applied), and the Army on missions (each center tied directly to a particular R&D command, highly applied). The USAF-supported portion of their FCRCs is focused on a well-defined support role — studies/analysis or systems engineering — but the FCRCs are free to diversify in other areas. Similarly, JPL has a prime responsibility for NASA (planetary missions), but it is also permitted to work in other areas and for other agencies. In fact, as a rule, NASA gives field project managers considerable authority and discretion, which builds flexibility into their system.

Alternatives to focusing on the ends of R&D include (1) concentrating on phases of the R&D process: basic research, applied research, development, etc.; and (2) looking at functions in terms of the purposes for which the government sponsors R&D: technology development for government purchase, applied research to fill gaps in the technology base, advancing science and technology, informing the policymaking process, and managing extramural R&D in the national interest (Office of Technology Assessment 1980).

Besides formal boundaries established by a parent agency, specifying that certain kinds of work are not to be done, it appears that the most common mechanism for limiting the breadth of a laboratory, frequently applied to GOGOs but not so often to GOCOs or FCRCs, is a combination of (1) personnel limits and (2) focused work assignments that require the available personnel. The NASA laboratories, other than JPL, and most of the DOD laboratories work within specified personnel entitlements, representing an estimate of the level of effort required to meet the sponsoring agency's needs; this tends to limit the breadth of the laboratory to the breadth of the sponsoring agency's current conception of its needs. Other mechanisms for control are mentioned in Sect. 4.4.

### 4.3.3 Work-for-others

Except for the smallest and most specialized ones, it appears that a great many federal laboratories — and even some corporate research laboratories — do work for other agencies and parties besides their parent agency.* For example, Navy laboratories conduct R&D for the USAF; NOAA laboratories for other agencies (roughly one-third of their work); NASA research centers for DOD, DOE, and others; and the NBS for DOE, industry, and others (more than 40% of its support). Only about $15 million of RAND's annual $40 million comes from Project Air Force, its FCRC role. The main differences seem to be between laboratories who accept work from other agencies because it is judged worthwhile to their own agency (e.g., NASA research centers and DOD laboratories), requiring a positive decision, and those who may accept work unless it is inconsistent with their parent agency's interests (e.g., JPL), requiring only the absence of a negative decision by the parent agency.† The former is usually associated with personnel ceilings and a relatively specific laboratory mission, the latter with an absence of ceilings and a broader mission.

In a number of instances, agencies have attempted to set limits to work-for-others by its laboratories. In the early 1970s, for example, NASA maintained a 15% limit on its research centers, although this constraint was later lifted. The DOD has kept a tight rein on nondefense work in its in-house laboratories (one policy statement, issued in 1974, limited such activity to 3% of the professional full-time equivalents in a laboratory, partly in recognition of Congressional disapproval of civilian research programs being carried out through the military). But it has been more permissive with its FCRCs and other contractor-operated research centers. A 20% guideline was operative in the late 1960s, but as RAND and others began to exceed it substantially, other mechanisms were developed to maintain a DOD-dedicated activity at those institutions. MITRE and Aerospace were allowed to create separate organizational units to carry out nondefense work and RAND redefined its original FCRC work as one unit within a larger independent institution.

Work-for-others raises two kinds of issues, aside from the quality and appropriateness of the work. If a critical function of a laboratory is to provide a single agency with R&D support, this function may be jeopardized by getting spread too thinly. Responsiveness may suffer, the best staff may be unavailable, and the identification with the sponsoring agency may be weakened. In addition, getting too far away from a single agency may reduce a laboratory's own security; a part-time supporter may be considered more expendable than a dedicated partner, especially if it lacks specialized facilities [NASA-Lewis appears to be an example (see Sect. 4.6)]. For these reasons, agencies and laboratories generally seek either to limit work-for-others, informally, or to find organizational ways to separate the different kinds of responsibilities.

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*Work for industry is discussed under the issue of "Relationships With External Institutions" (Sect. 4.5).

†Internally, such laboratories nearly always review proposals for work for others to assure that the laboratory is an appropriate place to do the work.

## 4.4 Planning Laboratory R&D Programs

A further issue is the role of laboratories in determining their R&D programs. DOE laboratories vary somewhat in this respect, but as a rule DOE, through the Office of Energy Research, establishes general guidelines; a laboratory develops a broad Institutional Plan in consultation with its cognizant Assistant Secretary and the appropriate field office of DOE; and R&D support flows from program office in DOE and elsewhere to laboratories on a task-order basis, consistent with this plan. Agencies other than DOE have adopted a range of practices that differ from this model, raising some interesting questions. For example, what difference does it make how a laboratory is connected with the parent agency? How much autonomy is desirable? Why? Should laboratories get R&D funding apart from task orders? If so, in what way, subject to which guidelines?

The answers of other agencies to these kinds of questions will be summarized in terms of three central issues: (1) the degree of independence given to laboratories in determining their R&D programs, (2) practices regarding R&D funding, and (3) the nature of the agency-laboratory relationship.

### 4.4.1 Independence

A recent unpublished study of national laboratories by the Office of Technology Assessment concluded that three factors have an especially strong influence on laboratory quality: the involvement of the agency in managing laboratory programs (i.e., micromanagement), the procedures used to assess performance, and the level of support for basic research (Office of Technology Assessment 1980). If so, the current trends are less than encouraging. According to several surveys, laboratory directors in many agencies are concerned that restrictions on laboratory authority to make technical decisions, formal management practices that add to the burden of paperwork, and the erosion of support for long-range basic studies and free-wheeling basic research are reducing laboratory capabilities and productivity (Office of Technology Assessment 1980; General Accounting Office 1979).

In agencies other than DOE, the degree of laboratory independence in determining R&D programs is handled in a great many ways, as one would expect. Generally, larger multipurpose institutions have more autonomy than smaller focused ones, and institutions devoted mainly to basic research are more self-determining in their programs than institutions whose work is more applied. But several agencies, at least, say that as a basic principle a high degree of autonomy is important, either at the institutional level (USAF research centers) or the project level (NASA). Certainly, RAND has considerable independence in choosing what it will or will not do, even within its FCRC role (Smith 1966), and this status is being maintained by both RAND and USAF in spite of the "dynamic tension" that it causes between them. The NBS is supported by specifically designated appropriated funds in the DOC budget, independent of DOC programs, giving it a special kind of autonomy. And the DOD has long pointed with pride to the independent basic research achievements of NRL and to other forward-looking roles of NRL as well [for instance, in 1939 it was instrumental in getting the government involved in nuclear matters (Kuhn 1966)]. One of the strongest reasons for stressing intellectual independence, of course, is that it is a key to attracting and retaining top people.

To get a broader perspective, it is worth looking at the practices of industry in this regard. The corporate laboratories of large industrial firms are in many ways equivalents of MPLs concerned with advanced, usually generic, R&D not directly tied to current production activities of the firm but related to general corporate goals. Working in a highly competitive environment, where productivity is measured in the marketplace, many of these laboratories "are classed among the top research institutions in the country" (Jeffries 1982). In achieving this kind of stature, a firm deals every day with the "difficult task of establishing strategic control without impairing the autonomy researchers need to perform their functions well" (Rosenbloom and Kantrow 1982).

As a rule, industry distinguishes between R&D conducted directly for operating units, where the activities are decentralized but research direction tends to be top-down, and R&D conducted at the corporate level, which is more centralized organizationally and geographically but more decentralized in the way projects are generated. In corporate laboratories, operating units are consulted about needs, but most of the decisions about program content are made by R&D management operating within a general agreement on objectives and priorities. Methods of corporate supervision are "strategic and not tactical" (Rosenbloom and Kantrow 1982). For instance, Exxon conducts its primary review of budgets for central research at five-year intervals. This appears to be the approach most likely to lead to real innovations, R&D breakthroughs, and long-term corporate growth (Hanson and Nason 1980).

Such an agreement on general policies does not mean that in either industrial or government laboratories the issue of independence is a simple one. Too much autonomy can lead to irrelevance. Too little interaction with the users of research can inhibit transfer. And one never strikes a balance that stays struck; as people and circumstances change, "independence" must be continually redefined and renegotiated. But for R&D institutions with relatively broad, long-range missions, the goal seems to be an essential one.

### 4.4.2 Institutional funding

Closely linked with the independence issue is the way laboratory work is funded. Federal laboratories vary considerably, from a situation in which all R&D support flows to a laboratory on a task-order basis to one in which a laboratory has considerable discretion in allocating funds to projects. The main alternatives to a strict task-order approach are as follows:

4.4.2.1 **"Level of effort" support.** A laboratory may receive a funding allocation each year based on the size of its staff, its buildings and equipment and the nature of its work. Agency programs then negotiate with the laboratory (and perhaps an agency coordinator) for their piece of the pie. This practice is quite common outside DOE. For example, each NASA research center receives a lump sum annually based on the size of its staff, its buildings and equipment, and the nature of its work; this covers such expenses as salaries and travel. In addition, a certain proportion of NASA's R&D support comes to the laboratory on a prorated basis related to the level of effort, covering such items as capital equipment, computer service, and other kinds of general R&D support. Clearly, this makes tasked R&D in such centers very inexpensive compared with a laboratory without such base support (such as JPL, for instance). NBS's specifically designated appropriated funds are another instance of this kind of support.

4.4.2.2 **General support for capability or concept development.** A laboratory may be authorized to set aside a portion of its R&D funding for discretionary activities, emphasizing the development of new ideas and capabilities to meet anticipated future agency needs. This can be handled either as a specific budget item, as in the case of the "competency building funds" approved in the FY 1979 budget for NBS, intended at that time eventually to reach a level of 15% of the total NBS budget, or the discretionary funds for DOD laboratory directors established as the result of a 1961 study of laboratory effectiveness. More often, though, it is treated as a kind of overhead allowance. For example, by agreement, a minimum of 10% of RAND's Project Air Force support is set aside for concept development, including new idea and proposal development.* It is reported that, in financing applied weapons development at several national laboratories, DOE itself includes off-the-top funding for capability building (Teich 1978).

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*In addition, with USAF concurrence RAND established a "20 Percent Policy": each senior researcher is entitled (and expected) to spend 20% of his or her time keeping abreast of developments at the frontiers of knowledge in relevant fields (Smith 1966).

**4.4.2.3 Laboratory authority to redirect funds.** Laboratories may be authorized to redirect R&D funding, subject to general guidelines and Institutional Plans, if they are still able to meet their commitments. At least within broad program areas, this can encourage laboratories to be efficient and innovative, and there are precedents for it in federal laboratories. In USAF research centers, for instance, laboratory directors have the authority to redirect exploratory development funds, subject only to general agency guidelines and a broad plan approved annually by USAF's Director of Laboratories.

In summary, we cannot say that a task-order approach to funding laboratory R&D is necessarily destructive of quality, because DOE laboratories dependent entirely on task-order funding have been able to develop reputations equal to any and superior to most; however, some of the alternatives might be worth considering.

### 4.4.3 The nature of the relationship

With the shifts from the Atomic Energy Commission (AEC) to Energy Research and Development Administration (ERDA) and then DOE, the nature of DOE's relationship with its laboratories has become blurred in the minds of many people on both sides; for instance, the link seems to be viewed in very different ways from program to program across the department. Other agencies vary in their interpretations of laboratory relationships, of course, but they generally seem to have a clearer and more consistent sense of this among the programs within the organization. NASA, for example, sees its centers and JPL as partners in its activities, not "contractors"; it is their policy not to establish field organization offices between NASA headquarters and the centers. The in-house research programs of the centers and the technical strengths they maintain are considered essential for NASA to be able to interact wth industry and make necessary decisions in an intelligent, well-informed manner. USAF sees RAND as its gadfly, helping to prevent tunnel vision and unrealistic oversimplification, and as its long-term think tank, an extension of USAF Headquarters. To the Army, its laboratories are mission-oriented problem solvers for its R&D commands. By contrast, NBS has relatively little direct relationship with the day-to-day activities of DOC, which contributes to its autonomy but leaves it without a strong constituency in its own agency (Teich 1978). This illustrates some of the existing views, indicating a range of useful relationships of federal laboratories and research centers with their sponsoring agencies.

At the outset, the DOE laboratories' GOCO arrangement was seen as a model for an agency/R&D institution partnership, preserving the flexibility and team spirit that had worked so well in the Manhattan Project (Hiestand and Florsheim 1969). It was recognized then that:

> The success of the concept depends in large part on the attitude and quality of the personnel involved and the kind of working relationship they develop. A failure to appreciate the

> 'partnership' aspect of the undertaking...can neutralize many of the advantages and benefits....(Hiestand and Florsheim 1969).

But with the rise of accountability and micromanagement during the 1970s, this sense of partnership has suffered in many instances. Because of their particularly close relationship with government, laboratories are probably the most sensitive of all the nation's R&D institutions to changes in the government environment.

The fact remains, however, that for laboratories in government and industry alike, interactions across the boundary between the R&D unit and the receivers of its work are at the core of its health as an institution. One study of industrial research, for example, has showed that R&D innovation depends more on organizational climate than organizational structure, [i.e., on personal relationships as well as formal lines of responsibility (Paolillo and Brown 1978)]. Between a laboratory and its non-R&D counterpart, these relationships are usually more difficult to maintain at lower ranks than higher ones, because of a larger difference in perspectives [e.g., between the "bench" scientist and the lower-level bureaucrat (Monteleone 1976)], but it is important for research managers at even relatively low levels to understand the requirements of operating units to which they relate. This demands care, patience, scrupulous attention, and a positive attitude from everyone involved, and it is not simply a matter of politics and public relations. Smooth and productive relationships depend on attention both to the communication process itself and to the substantive content of what is communicated (Smith 1966). Neglecting either, from either end, leads sooner or later to problems for the partnership.

### 4.5 Relationships with External Institutions

Perhaps the most pressing issue of all for DOE laboratories at this time is their relationships with external institutions, particularly industry and universities (see Sect. 5). At least with the private sector, DOE laboratories seem to have had fewer connections and an uneasier relationship than laboratories of certain other agencies. There are historical reasons for this situation, as well as different agency styles in dealing with people, but it is believed by some that changes are desirable in the rules of the game for DOE laboratories. For this, the practices of other agencies may be a good source of ideas, since they are entirely consistent with existing laws and regulations.

These practices fall into six categories: (1) patent policies, both regarding the work of internal staff and collaboration with industry; (2) policies toward subcontracting and program management; (3) policies toward R&D work with industry, apart from subcontracting and patents; (4) technology transfer activities; (5) university relations; and (6) relations with state and local governments.

### 4.5.1 Patent policies

Many agencies are perceived to have a more liberal policy toward patents than DOE. For instance, it is quite common and relatively simple for a firm working with NASA to get the rights to patents on devices developed with the support of public funds. In DOD, the usual practice is to give the contractor full rights to commercial use of a device, while the government retains the right of royalty-free use for government (i.e., military) purposes. An example is the joint USAF/industry/university R&D program in thermionic tubes, which has led to a number of private patents. The case of NASA is especially interesting because, unlike DOD, its formal statement of patent policy resembles DOE's. The difference has been in its liberal (and consistent) use of a waiver clause, communicating a positive and facilitative attitude to industry.*

As far as their own staff are concerned, some laboratories (such as NBS) simply state that all patents are government-owned. In other cases (such as the NASA research centers), however, staff members are given exclusive right to patents on work that is judged not to be in the direct course of their jobs. For instance, a staff member at NASA-Langley invented the wing used for hang-gliding; NASA determined that he had a right to receive royalties on his invention (although the patent expired before hang-gliding became the popular sport it is today).

### 4.5.2 Subcontracting and program management

Few other agencies involved their laboratories in as many kinds of subcontracting as DOE did in the late 1970s, but several of them assigned their laboratories important but narrower roles. For example, the NASA centers and Lincoln Laboratory often subcontract for the design and fabrication of equipment. In fact, the program management idea for a national laboratory is itself an application of a technique developed by NASA in the late 1960s; most NASA subcontracting is directly related to a mission responsibility of a center, an integral part of the way it does its job, and it often represents a larger proportion of the center's budget than at DOE laboratories. Similarly, as much as 75% of the advanced development work of USAF laboratories may be subcontracted, mainly for the procurement and testing of equipment. But the laboratories generally see themselves as doers of R&D, not intermediaries for it. For instance, RAND seldom subcontracts, although it makes liberal use of consultants, and NBS prefers not to get heavily involved in contracting, perhaps for reasons that are more historical than rooted in the purposes of the institution. In their energy work, NASA laboratories have tried to focus on work they can do themselves. But the issues are complex; for example, RAND has been criticized for being too ingrown in its work, at least partly because it has been unwilling to develop institutional links with other centers of excellence when a specific study seems to call for it. EPA laboratories, on the other hand, have been criticized for spending too much time administering extramural programs and too little on their own research programs (Teich, Lambright, and Flynn 1975).

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*A uniform government-wide policy on patent rights has been a goal of policymakers for many years (General Accounting Office 1982).

### 4.5.3 R&D work with industry

Aside from patents and subcontracting, agencies other than DOE vary considerably in their attitudes toward research collaboration with industry. At one extreme, RAND does no business whatsoever with the private sector, making a strict attempt to avoid any aura of conflicts of interest. NBS does considerable work for the private sector — calibration, equipment testing, evaluation of data, etc. — but it will not undertake work with individual firms leading to specific processes or products; most often, its services are arranged through trade associations (e.g., the American Society for Metals).* The DOD laboratories do not conduct R&D on contract from the private sector, but it is quite common for contractors to be working in-house at laboratories (usually either private firms providing support services or staff from nonprofit firms conducting research). Problems with proprietary information seem to be rare. NASA, which was created in part to nurture a new industry [and which was built around the heritage of the National Advisory Committee for Aeronautics (NACA), which in turn was set up during World War I to accelerate the development of aeronautics, first in the military and later in industry], works especially closely with industry;† but its laboratories are more likely to serve as analysts and reviewers than in joint R&D teams with industry. In a great many cases, work in the various laboratories and centers has led to the creation of spinoff companies, as new product or service ideas are identified which seem to promise new kinds of niches in the commercial world.

### 4.5.4 Technology transfer

Many federal agencies have involved their laboratories in technology transfer efforts. NASA, for example, has always stressed technology transfer, partly because the promise of technology spinoffs is a selling point for funding outerspace missions; it uses such means as periodic symposia, working through professional associations to reach potential participants, and even "adaptive engineering," modifying NASA technologies to suit particular users. EPA and the Department of Agriculture and Transportation have been especially active in technology transfer, probably aided by the decentralized, "grassroots" (some might say politicized) nature of much of their R&D support; and, although the DOD is its own main user of its technology, individuals in DOD and some of its centers (especially the Naval Weapons Center at China Lake) have been instrumental for a decade in setting up and operating such technology transfer frameworks as the Federal Laboratory Consortium.* Some of DOD's initiatives are mentioned under relations with state and local governments in Sect. 4.5.6. With the Stevenson-Wydler Act in place, specifying a role for laboratories, some of these activities may be increasing, but it is generally believed that the spinoff types of technology transfer from laboratories, as contrasted with direct programmatic transfers, still involve a substantial gap between what should be done and what is being done (Office of Technology Assessment 1980).

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*In the late 1970s, the Department of Commerce discussed the creation of a cooperative technology program, in which NBS would have served a program management function (Ambler 1978).

†For example, NASA has developed a Corporate Fellows program, a novel approach to government-industry relationships.

Industrial laboratories also have a great deal of experience with technology transfer, along both programmatic and spinoff lines. Unless a continuing stream of ideas from a corporate laboratory moves into commercial use, both the firm and its laboratory are in trouble. To avoid this, industry has found that direct, person-to-person contact between users and R&D people is essential. At least three kinds of mechanisms are commonly used (Roberts 1979).

1. Procedural approaches — tying together R&D units and appropriate receiving units by means of joint planning efforts. For example, Exxon Research and Engineering Company integrates laboratory R&D personnel into the process of preparing and reviewing planning documents (and personnel from user operations in major deliberations within a laboratory), and DuPont organizes joint efforts to develop technology assessments (Rosenbloom and Kantrow 1982).

2. Human approaches — encouraging the development of one-to-one personal relationships, often by moving people up or downstream [the transfer of personnel is often the best way to bring about technology transfer (Hanson and Nason 1980)].

3. Organizational approaches — creating special purpose integrative groups, with a foot in each world, to catalyze technology transfer. A hybrid version of this, with aspects of the other two approaches as well, is the creation of special product venture teams involving people from both R&D and downstream units.

None of these approaches is easy to use, and the management literature is full of discussions of how to do the job better. And there are some obvious differences between transfers from government laboratories to external users vs from corporate laboratories to units within their own firms. But the parallels are close enough to be instructive.

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*A key to the development of these networks has been the strong support of the National Science Foundation (Office of Technology Assessment 1980), filling a gap left by a general lack of agency support for such activities.

### 4.5.5 University relations

Non-DOE laboratories are linked with universities in a variety of ways (Federal Council for Science and Technology 1969). For instance, a seed-grant program at NBS supports research at 19 universities at a total of $2 million per year. In several cases, USAF has initiated university/industry research programs when they and their laboratories spot a gap in the technology base. For example, to get a gap-filling program going in thermionic tubes, USAF eqipped research laboratories at Stanford and Utah and helped the universities to develop courses to train needed technical experts. Similar efforts have been undertaken in such areas as composite materials for aircraft bodies — university-based, research affiliated with a stable laboratory structure which integrates research results with other developments in science and technology. Other laboratories are linked through co-location and even joint ownership and management. The most interesting case is the Joint Institute for Laboratory Astrophysics, cosponsored by NBS and the University of Colorado; it involves a remarkable degree of overlap, including the funding of some university positions by the Institute [which is widely praised as "a productive and an exciting place to work" (Teich 1978)]. In addition, many laboratories use teams of experts, including university representatives, as visiting committees to advise and help to evaluate laboratory work; one example is NBS, which contracts with the National Academy of Sciences to provide evaluation panels. Many laboratories have staff members holding joint appointments in university departments or teaching occasional courses for them.

Some federal laboratories and centers also maintain postdoctoral or visiting faculty fellowship programs, providing short-term professional opportunities for university personnel. For instance, NIH funds a floating pool of fellows out of its regular budget, rotating the slots to areas of greatest scientific need and interest, and NBS operates a postdoctoral program, with 40 to 50 fellows normally in residence for a two-year period.

Another kind of relationship between laboratories and universities is (in a sense) as competitors. Several federal research centers offer or participate in degree programs (see Sect. 5, page 102), and many of them seek funding for research similar to that carried out in universities (especially the laboratories involved in basic research). In this connection, a persistent issue has been the lack of a peer review process for most lab proposals and reports (Office of Technology Assessment 1980; Teich, Lambright, and Flynn 1975).

### 4.5.6 Relations with state and local governments

Several non-DOE laboratories have been innovative in offering assistance to state and local governments. For instance, the Naval Ordnance Systems Center, using an established federal program for public administration interns (IPA), has loaned staff members to local jurisdictions to help them with technical problems. As many as ten have been on loan at a time; the center pays a little less than half of the individual's salary, the local group the rest.* The same center has also made an effort to organize retirees as community volunteers. As an example of a more conventional kind of technical assistance, the Naval Underwater Systems Center, New London, Connecticut — as an outgrowth of an NSF program to encourage innovative programs in local governments — assisted the New York City Police Department in developing a fuel monitoring system, and other cities and states have shown an interest in copying the system. As a further example, the Naval Weapons Center at China Lake set up a program for the state of California to monitor and map in three dimensions the distribution of various aerosols in the state. And, through the efforts of the Federal Laboratory Consortium, a team from the Army Tank-Automotive R&D Command Laboratory in Warren, Michigan, was placed on the scene on very short notice after Mount St. Helens erupted to design and install an _ad hoc_ device to eliminate serious ash ingestion problems for emergency vehicles in the area. Within a day after arrival, an add-on air filtration system was ready for installation on Washington State Patrol (and other emergency) vehicles.

More generally, laboratories and their staffs offer assistance to state and local governments through the Federal Laboratory Consortium and such networks as the Community Technology Initiatives Program; but they lack guidelines for this kind of work, and its scope is limited by a number of very real constraints: shortages of resources, lack of strong support from agency officials, the demands of other missions, and in some cases statutory restrictions (Office of Technology Assessment 1980).

## 4.6 Policies During Retrenchment

Given our national commitment to get the federal budget in balance, some of the categories of work in DOE laboratories are certain to shrink. Since this process is already raising a number of management and policy issues for DOE and the laboratories, it makes sense to consider experiences of the federal agencies in the past with retrenchment in their laboratories.

There are two prominent examples of national laboratory retrenchment in the past fifteen years. One is the decision by USAF in the mid-1970s to trim its laboratory system, partly because of a shrinking budget and a need to increase certain work in armaments and communications, but also partly because of a sense that its R&D program had become too ingrown. Its policies and actions at that time are described earlier in this section (pages 66-67).

The other example is NASA, which went through a major contraction during the period 1967-1972 and has faced further budget cuts in 1977-1978 and 1981-1982. In the earlier period, NASA considered closing some of its centers (especially JPL), and it did in fact close one of them: the Electronics Research Center, the last NASA laboratory to be created. But, in general, it decided to try to preserve the technology base capabilities that had been developed in its laboratories. To do this, it supported laboratory directors in protecting their more basic research activities from budget cuts, giving up other R&D programs first; it tried to continue a reasonably steady flow of R&D support to the centers, sometimes at the expense of other institutions; and it encouraged its centers to look elsewhere for support (although it initially limited this work-for-others to avoid diluting their work for NASA itself). In a number of cases, the centers diversified actively, moving into energy and other R&D areas (and, in the 1980s, more heavily into DOD work), working under arrangements that sometimes differed from their traditional ones with NASA and DOD. In principle, when work by NASA center is defined by NASA as "worthwhile" to the agency, the non-NASA sponsor is not required to reimburse the salaries of staff contributing to it. As a rule, DOD work is so defined. On the other hand, as it evolved during the 1970s, work for DOE, Agency for International Development (AID), and other agencies involved salary reimbursement (which means that by implication this sort of work is not as worthwhile to NASA).

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*An Office of Technology study suggests that this particular mechanism could be expanded considerably (Office of Technology 1980).

This indicates a fundamental limitation of diversification (of work or of sponsorship) as a laboratory response to financial exigency. When an agency finds it necessary to make budget cuts, it looks for slack in its units. From the point of view of a sponsoring agency, a large amount of work for others may be interpreted as excess capacity: personnel and resources not essential for the agency itself. NASA-Lewis seems to be caught in this kind of bind, in contrast to NASA-Ames — which also diversified during the 1970s — but more cautiously, building on existing specialized facilities or acquiring new facilities so that "it could say it did something no other center did" (W. H. Lambright, personal communication).

At any rate, it appears from non-DOE experience that a number of options are available if an agency's laboratories are faced with possible retrenchment:

1. Clarifying the special roles and missions of each laboratory for the agency. One alternative is to refine the definition of a purpose for an institution and to protect those capabilities that are the highest priority for that purpose, giving up other programs and capabilities first. Presumably, the purpose would relate to both the existing strengths of the institution and the anticipated needs of the agency. Not all of such roles need be technology or resource specific (e.g., RAND's mission of "studies and analysis" for USAF defined in times of stringency in the mid-1970s).

2. Authorizing laboratories to seek support from other sponsors. Another strategy, followed by both DOD and NASA during the 1970s, is to enable laboratories to seek "work-for-others." The parent agency takes no responsibility for assuring a total level

of support; in fact, it may establish certain conditions for accepting other work. But, in essence, it interprets its laboratories as national resources, not just arms of the agency alone, and permits the laboratories to explore a wide range of ways that its capabilities may be the best for meeting R&D needs throughout the country.

3. Redirecting one or more laboratories. An agency may choose to redirect some of its laboratories, giving them new roles and shifting existing divisions and personnel as appropriate. For example, in the 1970s the USAF Cambridge Research Laboratories were converted from a basic research to an exploratory development institution.

4. Changing the status of one or more laboratories. A further option is to change the agency's portfolio of supporting R&D institutions by modifying the status of some of the parts: (e.g., changing a GOCO laboratory to an FCRC, changing an FCRC to a conventional contractor, or closing one or more facilities). In general, the intent is to reduce the responsibility of the agency for the R&D institution. One instance of this was the conversion of ANSER from an FCRC to a conventional consulting firm.

5. Changing the management structure for laboratories. Finally, an agency (or the federal government as a whole) may choose to change how it organizes and manages its laboratory system. For instance, during the 1970s USAF decided to combine four research centers with similar missions into a single management structure.

On their own, most well-managed laboratories faced with shrinking budgets will explore such options as #1, 2, and 3; and it may make sense for an agency to encourage both voluntary responses and some variety in those responses. Certainly, laboratories need some latitude if they are to maintain quality and morale in times of financial stringency. But if an agency wishes not only to preserve existing strengths but to introduce significant changes into the laboratory system, understanding the transition costs, it has a variety of options available to it.

### 4.7 Summary

The ORNL study of domestic models for the utilization of DOE national laboratories was focused on the five categories of issues described above: general ownership and management arrangements, breadth vs focus in defining laboratory purposes, relationships of laboratories with sponsoring organizations, laboratory relationships with external institutions, and experience during time of retrenchment. No magic answers can be found in the practices of agencies other than DOE, but one of the strengths of the federal research system in the United States is its great diversity, which assures a continuing supply of institutional experiments. Although DOE's laboratories are usually considered to be among the best in this system, some of the experiments elsewhere offer opportunities to make these laboratories even better.

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# 5. RELATIONSHIPS OF LABORATORIES WITH INDUSTRY AND UNIVERSITIES

T. J. Wilbanks

This section summarizes the current relationships of Department of Energy (DOE) laboratories with industry and universities, illustrating them by example. It then outlines some alternative strategies for laboratories in their external relationships, and it suggests a number of issues that are important in selecting a strategy to follow.

## 5.1 An Overview of Relationships

From the beginning, DOE laboratories have maintained a number of relationships with industry and universities, but many of the links have grown substantially in recent years, mainly because of changes in the needs of the government rather than because of spontaneous changes in internal management policy — or as a response to external criticism. This section will very briefly describe the major relationships, first outlining the principal mechanisms for relating to others and then illustrating the roles with respect to each of the two kinds of partners: industry and universities. Because of the limited scope of the effort, the examples are necessarily based more heavily on the experience of Oak Ridge National Laboratory (ORNL) than the experiences of other laboratories. As a result, although we hope that this section's coverage of roles and mechanisms is comprehensive, the cited cases should be considered illustrations of laboratory relationships, not an exhaustive list or even necessarily a representative sample of them.

## 5.2 Types of External Relationships

For national laboratories, external relationships are common and diverse. Most of them are two-party, in the sense that they are focused either on industry or academic, but some are deliberate attempts to foster a three-way link (Teich, Lambright, and Shelanski 1981). In some cases reflecting top-down initiatives by laboratory management, in others bottom-up initiatives by laboratory and other scientists, the most important mechanisms are the following.

1. **Technology transfer.** As science and technology performers, laboratories identify potential users of their products and try to get them used. This has always been a bottom-up "technology push" impulse, but it has also increased recently as a priority for top-down "demand pull" attention, stimulated by such government policies as the Stevenson-Wydler Act.*

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*Technology transfer as used here includes both applications for which a technology was originally developed, such as nuclear energy, and applications which are different, such as alternative uses of new materials (Morone and Ivins 1982).

2. **User facilities.** A prime purpose of national laboratories is to maintain and make available unique facilities needed by scientists and engineers in many institutions for their research and development (R&D) work. The emphasis has been on facilities of use to individuals, mainly in universities, involved in basic research, but there are examples of other kinds of facility use as well.

3. **Communication services.** Laboratories serve as catalysts and facilitators for scientific communication by (a) arranging a variety of ways for visitors and guests to spend time at a laboratory, often directly involved in laboratory programs, and encouraging laboratory personnel to visit industry and universities; (b) taking the initiative in setting up conferences and workshops on topics of national interest; and (c) helping to build and support communication networks that meet national needs, such as between academic disciplines, between industry and academia, and between policymakers and the research community.

4. **Contracting.** Laboratories contract with industry and universities for R&D, serving as a source of R&D support for the performers and as a source of technical direction and quality assurance for government programs — a role which for several laboratories has grown immensely since the creation of DOE. On occasion, they also contract from industry and utilities for R&D, and they perform work for other nonfederal sponsors as well, such as state and local governments.

5. **Other partnership arrangements.** Other joint arrangements include (a) direct collaboration in research, working together (most often on an informal bottom-up basis because the formalities can be difficult); and (b) complementary assistance, helping to meet each other's needs in such ways as providing quick-response technical assistance, serving on advisory committees, reviewing draft reports and proposals, and working together on committees and panels and in scientific and professional societies.

6. **Built-in institutional links.** Each of DOE's MPLs is in fact operated by a nongovernmental institution: a university or university association or for-profit or non-profit firm. Many of them are also linked to associations of regional universities, and some of them have developed special links with institutions in their own neighborhood [e.g., Los Alamos National Laboratory (LANL) and Sandia with the University of New Mexico and ORNL with Tennessee Valley Authority (TVA) and the University of Tennessee].

7. **Production activities.** In certain special cases, on behalf of DOE, laboratories are producers of devices and materials, not just developers of them (e.g., the radioisotopes produced at Oak Ridge and Los Alamos).

The next three parts of this section will illustrate these mechanisms as they work for (1) industry, (2) universities, and (3) three-way relationships among laboratories, industry, and universities. The overview will close with a discussion of external relationships with parties other than industry and universities.

## 5.3 Laboratory Relationships with Industry

Interactions with industry were common during the early years of national laboratories, as government and industry joined to build the nuclear energy enterprise. More often on a personal than an institutional basis, they continued through the 1960s and 1970s with utilities and firms involved with electricity in general and nuclear energy in particular. In the late 1970s the interactions increased dramatically, mainly because of a rapid expansion of subcontracting, and the substantial current interest in the relationship on the part of both partners is indicated by the very recent formation of a task force including representatives from the Industrial Research Institute (IRI) and eight of DOE's MPLs intended to encourage R&D cooperation between industry and laboratories.

### 5.3.1 Technology transfer

Activities of this sort have been under way for a considerable amount of time. Ever since the days of the Atomic Energy Commission (AEC), national laboratories have been charged with transferring to industry and other users the technologies generated by AEC/ERDA/DOE R&D programs. For example, the laboratories have historically been involved in shifting to the private sector technology associated with the nuclear fuel cycle (ERDA 1975). More recently, the DOE laboratories have been active participants in the Federal Laboratory Consortium for Technology Transfer, representing more than 200 federal R&D laboratories and centers. Recent instances of technology transfer to industry include LANL's "heat pipe," used on the Alaskan oil pipeline, and its flow cytometry and cell-sorting technology, its electronic identification technology for livestock control, a device for field treatment of cancer of the eye in cattle, and several technologies related to nuclear safeguards; LLNL's solar pond technology, being demonstrated by TVA and others; drilling technologies developed by Sandia, in cooperation with industry; other Sandia developments, including the solar total-energy system concept, an improved downhole steam generator for enhanced oil recovery, and a vertical-axis wind turbine; Lawrence Berkeley Laboratory (LBL) techniques for X-ray fluorescence analysis, magnetotelluric measurements, radioisotopic imaging, and using solid state ballasts for fluorescent lamps; Pacific Northwest Laboratory's techniques for processing radioactive wastes, decontaminating metal surfaces, improving high-speed manufacturing line inspection techniques, and conducting inhalation toxicology experiments; a process for separating rare earth metals developed by Ames Laboratory; and such ORNL developments as heat-pump hot water heater, techniques for ion implantation, a process that retrieves uranium economically during fertilizer production, materials such as the high-temperature alloy Hastelloy, and a variety of models of energy use (adopted by utilities, consulting firms, and other firms such as the Carrier Corporation). Every laboratory can cite a number of important contributions of this sort, and the beneficiaries include new companies, formed to make commercial use of laboratory-developed technologies, as well as established firms (Morone and Ivins 1982). Other examples are mentioned in the items to follow.

### 5.3.2 User facilities

Although there is a tendency to think that special laboratory research facilities are aimed more at university than industry users, such facilities are, in fact, widely used by industry as well. For instance, industrial scientists and engineers make use of the Intense Pulsed Neutron Source at Argonne National Laboratory (ANL), which provides high-intensity neutrons for materials studies; test reactors such as the Experimental Breeder Reactor-II (EBR-II) and the Transient Reactor Test Facility (TREAT); and a battery testing facility at ANL. Eleven industrial firms are members of the user's group for the Holifield Heavy Ion Research Facility at ORNL, and such firms as Exxon have used ORNL's small-angle neutron and x-ray scattering facility. Industry also uses the high-voltage electron microscopes at ANL and LBL, the National Synchrotron Light Source at Brookhaven National Laboratory (BNL), and the Solar Central Receiver Test Facility, the Photovoltaics Advanced Systems Test Facility, and the Combustion Research Facility at Sandia. These and other facilities are available to industry researchers at no cost if the results are to be published in the open literature; certain facilities may also be used for proprietary work, in which case the user reimburses the full cost of the effort. This, by the way, is a recent policy shift, resulting almost entirely by a determination of National Synchrotron Light Source staff to make their facility more readily available to industry; previously, industry was required to reimburse laboratories for the full cost of facility use, regardless of the type of research being performed.

### 5.3.3 Communication services

**5.3.3.1 Guests and visitors.** Industry leaders and research scientists and engineeers are frequent visitors to national laboratories, sometimes staying in residence for periods of weeks, months, or years. For instance, ORNL had 154 guest assignees (individuals given badges allowing them to come and go from the laboratory for a specified period on a day-to-day basis) from industry in FY 1980. ANL has formal industrial participation agreements with such firms as Exxon, Dow, Burns and Roe, Rockwell International, RCA, and major battery manufacturers. LANL has established a program for industrial staff members, under which scientists from private firms work, at company expense, in a laboratory research program for a year or more. Many of these people are involved in research collaboration or subcontracting. In addition, many visitors come for shorter periods. As an illustration of this, nine senior executives from industrial firms visited ORNL or had extensive contacts by letter and telephone in FY 1980 or 1981 concerning ORNL research on boride ceramics. As another example, about 200 people from industrial firms visited Sandia's Combustion Research Facility between January 1, 1981, and February 15, 1982.

5.3.3.2 **Conferences and workshops.** To foster the exchange of useful information, laboratories organize meetings on subjects of interest to industry. For example, in 1980 ANL arranged 24 meetings attended by 4700 visitors; a substantial percentage were from industry. In 1980, LLNL helped to organize a National Technological Cooperation Conference to discuss the challenges involved in transferring technological innovations from laboratories to commercial and industrial users, and LANL and Sandia recently cosponsored a Showcase for Technology conference, attracting 250 industry representatives to discuss opportunities for technology transfer and industry-laboratory cooperation.

5.3.3.3 **Maintaining communication networks.** Laboratories seek to provide liaison between federal R&D programs and the research needs and capabilities of industry, using such mechanisms as subcontracting, information dissemination, and advisory services. For instance, national laboratories provided summaries of the state of the art in key R&D areas, with particular attention to industry activities and roles, as part of DOE's technology base study in 1979-1981. In addition, they regularly communicate their own work to the public through their own journals, newsletters, brochures, and other publications.

### 5.3.4 Contracting

5.3.4.1 **To industry.** With the growth of federal energy R&D programs in the late 1970s, many national laboratories have vastly increased their subcontracting of R&D tasks to industry (not only manufacturing and engineering firms but also consulting firms and other private-sector institutions as well). Subcontracting at ORNL grew from about $6 million in 1974, not including major procurements, to more than $60 million in 1980. More than two-thirds of this subcontracting was to industry (more than $40 million in FY 1980); about half of that was for studies and evaluations and about half was for R&D leading to products. This type of laboratory role is expected to decline during the 1980s, but it will remain an important part of what laboratories do. Examples of subcontracting in recent years include work for ANL in the development of advanced batteries, solar collectors, components for nuclear reactors, and instrumentation for measuring and testing fossil energy plants; development of line-focus solar energy concentrators and borehole-logging techniques for Sandia; and work for ORNL in developing an alternative magnetic fusion technology [Elmo Bumpy Torus (EBT)], developing more energy-efficient appliances, improving the thermal performance of building envelope systems and materials, designing an atmospheric fluidized-bed coal combustion unit, developing the gyrotron as a source of energy for fusion plasma heating, and performing environmental impact assessments.

5.3.4.2 **From industry.** Industry funding for R&D performed at national laboratories is less common, but some support has been received from utilities and from industry groups such as Electric Power Research Institute (EPRI) and Gas Research Institute (GRI). It is generally believed that industry is reluctant to fund such work because of the length of time required to negotiate contracts, concerns about patent rights, and the high cost of "full-cost recovery;"* but recent changes in policy and procedure have improved the situation considerably, and further changes may be in the offing. At present, these concerns appear to be a bigger factor for large firms than small ones, because DOE has been more reluctant to grant exclusive licenses to large firms (Morone and Ivins 1982).

PNL's special arrangement for private funding may suggest other solutions for some of these perceived problems. At PNL, a unique use permit agreement with the federal government allows Battelle-Northwest, the laboratory's operating contractor, to use PNL facilities to perform private R&D, subject to reimbursement of DOE costs (Appendix D). Among other things, this has enabled a Battelle innovation to be adopted at PNL: the "group research project," in which a proprietary research effort is undertaken, supported by shares sold to industrial sponsors who thereby get access to the results. PNL has initiated several such projects; examples include studies of high-burnup fuel effects, fuel densification, and steam generator failures (Appendix D).

### 5.3.5 Other partnership arrangements

5.3.5.1 **Research collaboration.** Scientists at national laboratories often work closely with scientists in industry on subjects of mutual interest, sharing information and coauthoring research reports. Chemists at ANL and DuPont, for example, work jointly on neutron diffraction studies of catalysts, and research staff at ANL and Upjohn are working together to use the two-dimensional electrophoresis instrumentation developed at ANL. LANL and Schlumberger are collaborating in applications of theoretical models of multifield flow-to-flow calibration problems in tool design, and LANL is working with the Bonneville Power administration to develop a superconducting magnetic-energy storages system. Sandia has worked with major oil companies in investigating *in-situ* coal gasification processes and with Southern California Edison in developing the 10-MW(e) solar thermal pilot plant at Barstow, California. On a number of occasions, Sandia staff have conducted experiments in borehole logging and other subjects using facilities supplied by industry (by mutual agreement, without an exchange of funds). Metallurgists from ORNL have collaborated with researchers from Combustion Engineering, Incorporated, and other firms in the development of better steel alloys. Although questions about patents, proprietary information, and other matters sometimes complicate such cooperation if attempts are made to formalize it, it has been expanded considerably in the past few years as a consequence of new laboratory responsibilities for R&D program management. One example is the Large Coil Program, managed for DOE's Office of Fusion Energy by ORNL. This program is a cooperative laboratory-industry effort to develop advanced superconducting magnets, presently involving four laboratories and six major firms in four countries. Another example is DOE's Power Systems Technology Program, managed by ORNL, which uses a team approach to solve problems concerning electric utilities. Members of the team include individuals from the electric utilities, manufacturing firms, and consulting firms as well as ORNL and universities. The EBT-P magnetic fusion R&D facility at Oak Ridge illustrates a different kind of collaboration. In this case, ORNL developed the EBT concept as an alternative for fusion energy; industry conducted project-definition studies as a basis for proceeding toward development; using information from those studies, ORNL prepared a reference design which served as the basis for a request for proposal (RFP) for design and construction of a pilot facility; and McDonnell Douglas was selected as the contractor, under ORNL's general program management. ANL's Lithium/Metal Sulfide Batteries Development Project involved a similar kind of interaction with industry.

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*And because of a requirement that, before a laboratory can do work for a firm, the firm must demonstrate that the work could not be performed in the private sector, a requirement that can be difficult to satisfy (Morone and Ivins 1982).

5.3.5.2 **Technical assistance.** Laboratories provide quick-response assistance to industry when technical problems arise. Support from ORNL, LLNL, and other laboratories at the time of the Three Mile Island incident was a dramatic example of the ability of laboratories to help utilities and other firms on short notice. Another example is Sandia's support to firms and utilities undertaking experiments with photovoltaic systems.

5.3.5.3 **Other complementary assistance.** Laboratories and industry quite commonly assist each other in such ways as providing advice for program development. For example, individuals from industry serve on the advisory committees for twelve divisions and programs at ORNL, as well as the Laboratory's overall Management Advisory Council. In the process, a great deal of information is exchanged about R&D activities, public vs private roles, and priorities for federal R&D support. As another example, in April 1981 vice-presidents or heads of research of 26 leading corporations visited ORNL to provide advice on the planned High-Temperature Materials Laboratory (also see Morone and Ivins 1982).

### 5.3.6 Built in institutional links

Three multiprogram laboratories (MPLs) are operated for DOE by profit or not-for-profit firms: ORNL by Union Carbide, PNL by Battelle, and

Sandia by Western Electric.* In addition, some of the program-dedicated laboratories are operated by private firms. Laboratories have also developed special relationships with such public-sector corporations as TVA and the Bonneville Power Authority, although these relationships are still rather limited in scope and intent.

### 5.3.7 Production activities

Certain devices and materials produced by laboratories for DOE are purchased by customers in the private sector. An example is the production and distribution of stable isotopes and radioisotopes by ORNL and LANL, none commercially available from other sources in the United States, which are widely used for such purposes as producing commercial radiation sources and radiopharmaceuticals for nuclear medicine. In addition, laboratories are important customers for industry; for instance, during FY 1981 Sandia made nearly 94,000 purchases from 11,700 commercial sources, totaling about $300 million (more than half from small business).

## 5.4 Laboratory Relationships with Universities

In a sense, DOE national laboratories originally formed as offshoots of universities, and their continuing involvement in basic research and their provision of unique facilities for it have kept them in touch with the community of scholars. The laboratories, however, have varied considerably over the years in their relationships with universities. In general, the relationships have been closer where laboratories are located in proximity to universities and where security restriction are not a major factor. Where laboratory staff and management are interlocked with those of a university, as with LBL, the connections have been especially close. From time to time, however, these laboratory-university associations have been rather fragile, and laboratories have often sought to improve them by allocating internal resources for such things as visiting appointments.

### 5.4.1 Technology and information transfer

In addition to the transfer of technologies benefiting universities to commercial developers (such as instrumentation), laboratories transfer their research findings to the world of scholarship through open-literature publication and participation in professional meetings. For example, staff members at the eight large MPLs published 2600 papers in refereed journals in 1977. In physical science, engineering, and technology journals, the laboratories as individual institutions were comparable in their research productivity with the nation's leading universities and private research centers.

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*In the case of PNL, the link is quite strong (Appendix D). In contrast, Sandia and ORNL are relatively independent of their operating firms, except for administrative processes; but their ties with Western Electric and Union Carbide seem to have influenced their styles and personalities in ways that facilitate other relationships with industry.

### 5.4.2 User facilities

As mentioned previously, one reason for the existence of laboratories is the opportunity to offer special "big science" facilities to the larger research community. Many of these facilities are made available at no cost to the user, as long as the research is not proprietary; in some cases, users are even provided with travel and subsistence expenses when they have no other source of support available to them. Other facilities are available if laboratory operating costs are reimbursed. ANL, for example, maintains eleven major user facilities, seven of which involve no charges for most nonprofit use. In FY 1980 more than 80 user groups were carrying out experiments on them. ANL Director, Walter Massey, has reported that for one new facility alone, the Intense Pulsed Neutron Source, ANL has 120 proposals for experimental work in FY 1982, far more than could be accommodated if the device were run 24 hours a day for an entire year (U.S. House Committee on Science and Technology 1981). Other laboratories have had similar experiences. ORNL, for instance, maintains seven major user facilities, plus four research reactors and three other complexes of research facilities (in biology, fusion, and solid-state science); these facilities are used by about 130 universities. In just one case, the Holifield Heavy Ion Research Facility, the user group includes 70 American universities, plus 14 from other countries. User facilities at other laboratories include the National Synchrotron Light Source and the 60-in. Cyclotron at BNL, the new multifacility Combustion Research Facility at Sandia-Livermore, the Central Receiver Test Facility at Sandia-Albuquerque, and the Los Alamos Meson Physics Facility.

### 5.4.3 Communication services

**5.4.3.1 Guests and visitors.** National laboratories host a steady stream of scholars, teachers and students. In many cases, these visits involve temporary appointments at the laboratory. Typically, for example, ORNL, ANL, and BNL will each have about 1000 university faculty members and students in residence for all or part of a year, participating in Laboratory research programs and exchanging professional insights with laboratory staff. For instance, the Division of Educational Programs at ANL operates eight programs for visiting faculty, eleven for graduate students, six for undergraduate students, and two for high school students. Guests from universities at BNL during 1981, including research collaborators, were affiliated with 123 U.S. colleges and universities and 46 foreign universities. These opportunities for participation and interchange bring many of the best minds in the nation to the national laboratories, and they contribute to building and maintaining a pool of trained manpower for energy R&D.

They also enrich the intellectual environment at laboratories, contributing to the flow of ideas that "distinguishes a genuine intellectual organization from a business" (Orlans 1972). In addition to visits by university people to laboratories, laboratory staff are also regular visitors to universities. In FY 1981, for example, staff members from one of ORNL's 15 research divisions presented 13 invited lectures at universities across the country.

5.4.3.2 **Conferences and workshops.** Many of the conferences organized by laboratories are aimed primarily at the research community in a field of interest to DOE or another laboratory sponsor. For instance, in 1980 ORNL organized a technical symposium on the mushrooming subject area of health risk assessment. During that same year, more than 1200 university faculty members came to ANL for such conferences and seminars. Examples included conferences on biological aspects of ecosystem radiation and synthetic fuels prospects and problems. And the annual Hanford Life Sciences Symposium at PNL is a major event in the Northwest, drawing participants from government and industry as well as universities.

5.4.3.3 **Maintaining communication networks.** One of the most important but least publicized roles of national laboratories is as a communication link between policymakers and the frontiers of research, talking to each community in its own language, translating and interpreting messages between them. Laboratory staff seek to communicate research needs to disciplinary groups (e.g., ORNL initiatives in the social sciences) and research findings to federal program offices (e.g., the technology-base summaries for DOE). They interact with university faculty members who have research ideas but do not know where to take them, making a particular effort to identify and encourage capabilities in their own regions. They interact with program offices which have specialized research needs but do not know where to direct them. In some instances, they take the initiative in setting up new frameworks to bring researchers together; an example is the role of ORNL in creating the Society for Risk Assessment and its journal. Most of this service is provided as a kind of overhead item, related to a laboratory's special character as a bridging institution.

### 5.4.4 Contracting

Laboratory subcontracting to universities is not as large in total dollars as to industry, but it is extensive nonetheless. For instance, in FY 1981 the nine MPLs subcontracted $55 million with universities, adding about 20% to the $289 contracted directly from DOE. The university research funded by national laboratories in 1980 ranged from quite basic to quite applied; examples included oceanographic research associated with the possibility of disposing radioactive wastes on the deep-ocean floor (Sandia), a variety of research on advanced battery concepts (ANL), and carbon biogeochemistry research intended to understand the carbon cycle better (ORNL).

### 5.4.5 Other partnership arrangements

5.4.5.1 **Research collaboration.** Besides separate subcontracts, university faculty and graduate students work jointly with laboratory staff on many research programs. For instance, university personnel contributed more than 400 person-years to ORNL's programs in FY 1980, representing about 20% of the Laboratory's total in-house research effort for the year.* At LBL, about 160 members of the Laboratory staff hold joint appointments at the University of California, and more than 500 Ph.D. students are in residence at the Laboratory at any given time. An example of a tangible outcome from such collaboration was the development of an artificial kidney by ANL working jointly with the University of Chicago Medical School. Current efforts include the collaboration of ORNL and the Massachusetts Institute of Technology (MIT) in studying mechanical and microwave properties of ceramic materials used for the "windows" of gyrotrons, cooperation between Sandia and the University of Texas at Dallas in seismic experiments related to DOE's Magma Energy Research Project, and collaboration between Sandia, Cornell University, and the Naval Research Laboratory in research on generating and controlling ion beams for inertial confinement fusion.

5.4.5.2 **Technical assistance.** Laboratories have provided practical assistance to universities in the use of new technologies and practices of many sorts. As one example, more than 125 two-year colleges have adopted an energy conservation plan developed by LBL, thereby reducing operating costs in a budget category that has been especially troublesome in recent years. Another case is Sandia's assistance with photovoltaic system application experiments by university staff.

5.4.5.3 **Other complementary assistance.** Laboratories and universities help each other in still more ways. Laboratory facilities may serve as the focus of technical degree programs at a nearby university: for example, the biomedical graduate degree programs of the University of Tennessee located in the Biology Division at ORNL. Or laboratory programs may be used to help give students practical experience, as in the case of the MIT Practice School at ORNL for engineering students. University faculty members and administrators serve on the advisory committees of sixteen ORNL divisions and programs, together with the Laboratory's Management Advisory Council. Laboratory staff and administrators frequently serve as evaluators of university programs or advisors to them, and laboratory personnel are heavily involved in reviewing proposals for research support submitted to DOE, the National Science Foundation (NSF), and many other agencies.

In at least two cases, educational collaboration has become considerably more extensive and formalized than this. As mentioned above, half of the staff at LBL, co-located with the University of California at Berkeley, are faculty members at the University, and more than 500 graduate students are supported by the Laboratory. At Richland,

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*A small fraction of this effort was supported by DOE's University/Laboratory Cooperative Program.

Washington, Battelle-Northwest/PNL was one of the founders of the Joint Center for Graduate Study, an educational center operated by the University of Washington and Washington State University, with the cooperation of Oregon State University. About 70% of the faculty of the center are PNL staff, who make it possible for both degree programs and continuing education programs to be offered to local residents.

### 5.4.6 Built-in institutional links

Six DOE MPLs are operated for DOE by universities or associations of universities: LBL, LLNL, and LANL by the University of California; Ames Laboratory by Iowa State University; ANL by the University of Chicago and the Argonne Universities Association; and BNL by the Associated Universities. Laboratories have also developed and, in many cases, are rapidly strengthening formal relationships with other nearby universities, such as ORNL with the University of Tennessee and LANL with the University of New Mexico (LANL's link with the University of California is weakened by its distance from it).

Besides their roles in operating national laboratories, associations of universities have historically contributed to laboratory—university relationships in a number of other ways. Oak Ridge Associated Universities (ORAU) is an example. An association of more than 50 colleges and universities, mainly in the Southeast, it was established in 1946 (as the Oak Ridge Institute of Nuclear Studies) to make the intellectual and physical resources of ORNL more readily available to the universities in the South, especially as the universities sought to develop education in new nuclear-related fields. For instance, in 1948 AEC asked ORAU to explore with its associated medical schools their interest in a clinical program for cancer research using radioisotopes. The interest was strong, and such a program was established. Like many other roles of university associations, this activity has evolved from what began as a potential for a laboratory—university relationship into a continuing program of the association itself, only indirectly related to ORNL. But ORAU still administers DOE-supported faculty and student research and training programs at ORNL and other facilities, encourages its members to take advantage of user facilities at ORNL, organizes a traveling lecture program (relying heavily on ORNL speakers), and helps to publicize special opportunities within ORNL for universities and university scientists.

### 5.4.7 Production activities

Certain devices and materials produced by laboratories for DOE are essential for university research and services. For instance, the radioisotopes produced by ORNL and LANL are used in medical schools and university teaching hospitals throughout the United States.

## 5.5 Three-way Relationships

In addition to these two-way relationships of laboratories to industry and laboratories to universities, laboratories have also tried to serve as a kind of catalyst for industry-university relationships. Such three-way linkages, nearly always initiated by the laboratories and DOE, were recently summarized in a report to the National Science Board (Teich, Lambright, and Shelankski 1981).

The report cites examples of this function through subcontracting (ANL's high-performance battery program, Sandia's subseabed disposal project, and PNL's aquifier thermal energy storage project), user facilities (ANL's Intense Pulsed Neutron Source, ORNL's Holifield Heavy Ion Research Facility, Sandia-Livermore's Combustion Research Facility, and BNL's National Synchrotron Light Source), education and information exchange (ANL's Fusion Residencies and PNL's Hanford Life Sciences Symposia), and technology transfer activities (ANL's solar collectors, LANL's radiopharmaceuticals, and LLNL's technology training program). Another case, including user facilities, information services, and collaborative research, is the Fusion Engineering Design Center headquartered at Oak Ridge, supported by seven laboratories, seven large industrial firms, and six major universities. Laboratory, industry, and university personnel have all been involved in leadership positions in the center. Although these kinds of three-way relationships are still relatively uncommon — and unlikely to arise spontaneously — the authors found no policy barriers to them, except possibly for uncertainties about patent rights.

## 5.6 Other Relationships

This overview of relationships with industry and universities is only a part of the total picture of external connections of national laboratories. Important linkages also exist with such other entities as foreign countries, federal agencies other than DOE, state and local governments, and government corporations (e.g., TVA). No attempt will be made here to survey these relationships, but several of them will be mentioned again in the next two sections.

## 5.7 Alternative Strategies for Strengthening the Relationships

Although the relationships between national laboratories and their external partners are certainly extensive, all the parties agree that they could be expanded and improved. Clearly, these linkages are at the heart of getting full value out of the laboratory system (U.S. House Committee on Science and Technology 1981; Comptroller General of the U.S. 1978).

Toward this end, a number of alternatives are worth considering. Without trying to be exhaustive, this section will provide some illustrations of the range of possibilities. First, some alternatives for improving laboratory relationships with industry will be outlined. Then, some options for relating laboratories more positively with universities will be described. Finally, several other possibilities will be mentioned: laboratory relationships with state/local government, with government corporations, and with their regions.

### 5.7.1 Strengthening laboratory relationships with industry

The major options of this sort involve finding better ways to work together, some possible new roles for laboratories, and serving as "bridges" between industry and government.

5.7.1.1 **Working together.** It will be a challenge to improve the record of the national laboratories in working with industry during the same turbulent time that the responsibilities for the various parts of the R&D sequence are being shifted from party to party (ERAB 1981). In fact, an industry spokesman recently observed that there seems to be "a false perception by government that we only do long range research, industry only does short range development. Such a perception... drive[s] a further wedge between the National Laboratories and industry, just at a time when the potential benefits of closer cooperation of National Laboratories in industrial R&D are beginning to be appreciated" (Jeffries 1982). There may be some promise, however, in looking at four possibilities.*

*Improved conditions for cooperative work.* It is not clear that formal DOE policies on patent rights, proprietary information, and similar matters need to be changed, but it does appear that they need to be communicated to industry more clearly to reduce the considerable hesitancy in industry about using laboratory facilities and collaborating in laboratory programs. It also appears that a "fast-track" procedure for making decisions on patent rights would be an asset. In addition, the "use permit" idea in use at PNL, which allows collaboration on proprietary research, deserves further study to see how it might be adapted for wider use, and it might be worth exploring the possibility of allowing laboratories to join with industrial firms in responding to certain kinds of RFPs (Morone and Ivins 1982).

*Increased support for technology transfer.* Although everyone — within laboratories and without — advocates more attention to transferring technologies developed within national laboratories to users in the private sector, R&D programs seldom include financial support for this "marketing" activity. If it were supported explicitly, not only would a greater effort be made in many cases, but accountability would be easier to establish. This might be especially important in the next several years, as laboratories move the most frequent point of transfer farther back toward the basic end of the R&D process, having to develop new personal contacts and marketing strategies as a result.

*Increasing the motivation for laboratories and laboratory staff to get their inventions into use.* One possibility would be to give laboratories the right to license their own inventions, with all or part of the proceeds made available to the laboratory for discretionary R&D. With this incentive, laboratories could be expected to work harder to transfer their technologies to others. Another alternative, also involving the licensing of commercial applications of laboratory inventions, would be to let the individual inventor(s) retain patent rights under certain conditions. DOE apparently has a liberal policy toward assigning patent rights to inventors upon request, and a number of laboratory employees have been successful in keeping patents and getting their technologies into commercial use.

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*A fifth is also worth noting briefly: laboratory cooperation in developing nearby industrial parks, in cooperation with neighboring universities.

*Improving the process of communicating ideas to industry.* The alternatives include staff exchanges with industry, specific funding for technology transfer activities by laboratories, staff departures to undertake commercial ventures, and increased attention to laboratory "show and tells" — annual "technology fairs" for industry, displays at meetings and conferences, etc. (also see the next item below).

*Increased involvement of scientists or managers from industry as advisors to agency and/or laboratory programs, possibly in a formalized process.* Again, just as with universities, using industry representatives as advisors to public-sector R&D programs should be a common practice. There is no other way that is quite so effective for assuring that public expenditures are useful to industry and non-competitive with it.

5.7.1.2 **Expanding laboratory roles in directions that meet particular national needs.** A further possibility is expanding the contributions of national laboratories to meet some particular needs for industry R&D. Four cases, at least, seem to be worth considering: (1) an increase in laboratory R&D on contract from industry, where the laboratory has unique equipment or special expertise, a firm has a one-shot R&D need and wishes to avoid inefficient investments in internal capabilities in order to do the job in-house, or a number of firms see a common need for generic R&D support and problem solving; (2) a specific role for national laboratories in providing R&D support for small industry, which is less likely to be able to meet its R&D needs internally [i.e., user facilities for certain kinds of technology development (e.g., buildings?)] as well as for basic research; (3) a special role in supporting energy utilities, where patent rights and proprietary information may represent less of an obstacle; examples include problem-solving applied R&D, particular kinds of user facilities, and staff exchanges to provide professional enrichment for utility technical staff; and (4) the development of a strong relationship between national laboratories and public-sector corporations such as TVA, Bonneville, and Synthetic Fuels Corporations.

5.7.1.3 **Increased emphasis on the role of national laboratories as "bridges."** At a time when there are compelling reasons for government and industry to work together cooperatively to make the U.S. economy more competitive internationally, national laboratories have the potential to serve as bridges between government and industry, buffering such concerns as the inevitable one about conflicts of interest. Program management and subcontracting roles are a key to this, along with a laboratory ability — as an institution without a vested interest — to evaluate and communicate information about industry activities, capabilities, needs, and responses to policy initiatives.

## 5.8 Strengthening Laboratory Relationships with Universities

Laboratories could build stronger linkages with universities by increasing their educational roles, expanding their provision of user facilities, paying more specific attention to their roles as "bridges" improving communications with university personnel, finding additional support for cooperative programs, and enhancing the roles of university associations.

### 5.8.1 Roles in education

For twenty years or more, various observers have suggested that national laboratories should play a greater role in education (Weinberg 1962; Moravcsik 1970). Proposals in the past have ranged from simply increasing programs for visiting scholars to Weinberg's suggestion that many laboratories be converted into institutions like MIT, directly involved in educating Ph.D.'s in the sciences.* At present, the main opportunity seems to lie in helping the nation to cope with resource shortages in the universities — faculty, doctoral students, equipment, and research support in science and engineering fields. To help meet these needs, perhaps laboratory roles in education could be expanded, although this would have to be done with considerable delicacy to avoid competition with universities.† The existing regional associations of universities might serve as one way to match laboratory capabilities with university needs.

### 5.8.2 More user facilities

With scientific equipment increasing in sophistication and price at the same time that many universities face tightening budgets, it seems likely that costly instruments will have to be shared more often in the future. NSF is already experimenting with regional instrumentation facilities for analytical chemistry (see *Industrial Chemical News*, February 1982), and DOE laboratories could go far beyond their current capabilities in providing facilities. For example, they could arrange loans of relatively mobile equipment, as well as offering sites and user arrangements for large, immobile items.

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*As an example of this kind of development, RAND has established the RAND Graduate Institute to provide graduate education leading to a doctoral degree in policy analysis. By 1981, entering its twelfth year, the program had granted 21 doctoral degrees and about 50 graduate fellows were in training (doctoral dissertations involve work on RAND projects, for which students are compensated). Another case was the Woods Hole Oceanographic Institution, which developed a joint degree program with MIT in 1967.

†Examples of options include staff members jointly appointed with nearby universities, others serving as visiting faculty where gaps exist, staff exchanges to provide professional enrichment for personnel from both universities and laboratories, faculty support in connection with laboratory research programs, students working on laboratory research projects (on higher salaries than normal stipends) while they pursue graduate degrees, increased faculty and students use of laboratory facilities, and a laboratory role in helping science and engineering faculty in two- and four-year institutions keep up-to-date technically.

### 5.8.3 Laboratories as bridges

At a time when federal agency budgets are tight, and science and technology research money (at least from public sources) appears to be shrinking, agencies are especially concerned about using their resources well. As R&D extensions of a federal agency, laboratories have a better appreciation of agency program needs and styles of work and communication than do most universities, and as research institutions themselves, laboratories have a better appreciation of university strengths and styles of work and communication than do most agency programs. This puts national laboratories in a position to play a unique role as a bridge between these two different worlds. Such a role would be enhanced by using laboratories more often to manage R&D programs focused on contracts with universities, to represent and explain agency programs to professional groups, and to bring developments on the research frontier to the attention of agency programs.

### 5.8.4 Increased involvement of scientists or administrators from academia as advisors to agency and laboratory programs

Using university representatives more often to help determine what activities make sense for laboratories and to evaluate and help improve those activities would aid in getting the various parties better acquainted. It would also help in creating beneficial linkages, communicating information about each other, and reducing unnecessary overlaps.

### 5.8.5 Increased support for cooperative programs

The use of visitor/guest programs and cooperative research opportunities would be increased if there were more incentives for them. For example, there is very little specific financial support for university participation in laboratory programs or for interchanges between the two kinds of institutions. An increase in the resources available for such activities might pay off handsomely, especially at a time when many universities themselves are struggling with penurious conditions.

### 5.8.6 Enchanced roles for university associations

Most of the DOE laboratories have developed relationships with universities through a formal consortium; in fact, two of the laboratories are operated by such consortia: the Argonne Universities Association (ANL) and the Associated Universities, (BNL). In general, however, these associations have had to struggle along without much of a fiscal base for initiating substantial university-laboratory cooperation. A more clearly-defined role, together with adequate financial support for the purpose, could transform these associations into the nation's primary mechanism for laboratory-university interaction.

## 5.9 Strengthening Other Laboratory Relationships

Besides industry (in the private-sector sense) and universities, several other categories of laboratory external relationships deserve attention: state/local governments, government corporations, and their regions.*

### 5.9.1 State/local governments

A growing type of activity for federal laboratories (DOE and other) is technical assistance to state and local governments. Examples include LLNL's service in training employees of the city of San Jose to use microcomputers for traffic control (the new traffic-control system saved the city $175,000), Sandia's assistance to a New Mexico community in using thermal radiation to treat sewage, and ORNL's management of an effort to determine the feasibility of a district heating/cogeneration system for the Minneapolis-St. Paul area. The "new federalism" may increase the needs of state and local governments for such advice and assistance, and the Stevenson-Wydler Act (Pub. L. 96-480) provides a mandate for laboratories to play this role. For nearly a decade, national task forces have been suggesting that federal R&D laboratories should be doing more for levels of government besides the federal (Federal Council for Science and Technology 1974; Council of State Governments 1973).

### 5.9.2 Government corporations

A number of public-sector corporations exist to accomplish energy-related tasks, such as TVA, Bonneville, and, more recently, the Synthetic Fuels Corporation. It is possible that a similar corporation may take shape to build the liquid metal fast breeder reactor. Where corporation needs are well-matched with laboratory capabilities, it might make sense for the public-sector laboratories to develop an especially strong relationship with these entities, just as, say, Bell Laboratories relates to Western Electric.

### 5.9.3 Regional roles

Because of their affiliation with regional associations of universities and field operations offices of DOE and because of the ways that distance tends to attenuate contact networks, most of DOE's MPLs have always had a closer tie with their own regions than with the rest of the country. This tendency was strengthened in the mid-1970s when ERDA assigned six of the laboratories a specific responsibility for analyzing energy and environmental conditions in their respective regions, and several laboratories have taken further initiatives to serve as a "window" between federal programs and their regions: focusing on their surrounding areas a considerable part of their efforts in technology and information transfer, assisting state/local governments, and serving as catalysts for energy-related university research. Although the national laboratories are determined to maintain their identities as national centers rather than regional ones, their regional roles could be enhanced as part of a more general drive to increase external relationships.

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*A further possibility, strengthening relationships of DOE laboratories with federal agencies other than DOE, will not be discussed here.

## 5.10 Issues in Selecting a Strategy

All of these possibilities are worth studying, and all of them have a certain amount of appeal. In making decisions about strategies to follow, however, several issues will have to be confronted. How these issues are resolved will largely determine the choices to be made.

### 5.10.1 Laboratory motivations for external relationships

Aside from idealism, perhaps, there is no intrinsic reason for laboratory managers to stress external relationships. Their abiding concerns are with such matters as mission fulfillment, institutional vitality, and the financial well-being of their organization (Teich and Whartnaby 1976). Such external linkages as technology transfer activities mainly benefit users, not providers. As a result, there is a natural tendency to treat external relationships as an aspect of public relations rather than as a central purpose of the institution (Morone and Ivins 1982). Changing this situation would require making external linkages an explicit part of the mission of a laboratory, a contributor to its financial health, and/or a compellingly important part of its intellectual vitality.

### 5.10.2 Laboratory resources for external relationships

There is very little specific financial support for laboratory relationships with industry and universities, especially technology transfer efforts and interchanges of staff. But enhancing these relationships requires resources: not only money but also people and time. Laboratory interactions reflect agency viewpoints and policies about laboratory roles, as represented by the allocation of these resources. In many ways, expanding these interactions awaits agency action to make it possible.

### 5.10.3 The rules of the game for government-industry relationships

As mentioned above, many possibilities for collaborative work between laboratories and industry are hampered either by uncertainties about the rules of the game or by impediments presented by those rules. A number of federal policy initiatives now under discussion could lead to real breakthroughs in developing new kinds of partnerships;* but their future is uncertain at this point (as is the attitude of the American public toward such collaboration in the long run).

### 5.10.4 Impacts of changes in federal roles

Finally, if the federal role in energy R&D comes to be limited almost entirely to basic research and a few areas of long-range, high-risk technology development, laboratory relationships with industry and universities will be affected. Some will be curtailed, such as subcontracting and program management. Some, such as technology transfer, will have to be reconstructed. Some, such as basic energy research, may be complicated by an increased sense of competition. Some may in fact be stimulated (e.g., laboratory-industry collaboration). But the multipurpose DOE national laboratories will certainly have to find their way in a new kind of institutional environment.

These issues indicate that this is a critical time for the external relationships of national laboratories. The potential for far-reaching improvements is considerable, but these potentials are unlikely to be reached without deliberate action by the federal government as well as by the laboratories themselves.

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## 6. USES OF LABORATORIES FOR TRAINING INDUSTRIAL R&D PERSONNEL

**T. J. Wilbanks**

This section provides a brief overview of uses of the Department of Energy (DOE) laboratories for training industrial research and development (R&D) personnel and suggests three ways that such uses might be enhanced in the future.

### 6.1 An Overview of Training Roles

The roles of DOE laboratories in training industrial R&D personnel are limited. Because education and training are fundamental roles of universities in this country and because industrial firms often provide their own training programs for employees, specific training activities by a laboratory have generally been considered unnecessary and inappropriate. Under a particular set of circumstances, however, laboratories have taken on such responsibilities in the past, and they continue to offer a few short-courses and other short-term training programs in specialized areas. In addition, they play an important *indirect* role in R&D manpower training, and they are often affiliated with university associations which are directly involved in training activities.

### 6.2 Direct Laboratory Role

As a rule, federal R&D laboratories have only developed specific programs to train industrial R&D personnel in situations where (1) it is in the national interest to create a new technology-oriented industry (such as nuclear power, aerospace, or certain defense production activities), (2) the development of the science and technology base for the industry will, at least at the outset, be a public sector responsibility, and (3) colleges, universities, and industry itself are unprepared to furnish the necessary training and support. In many cases, national security has also been a a factor; when some of the training involves a security classification, sites other than universities are more likely to be necessary.

The only major example concerning energy laboratories has been nuclear energy.* By the end of World War II it was clear that realizing the potential for peaceful uses of atomic energy would require not only a new industry but also a set of new technical specialties, such as

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*Some parallels exist in the roles of NASA laboratories in helping to build the aerospace industry, although most of the contributions to personnel training as such seem to have been indirect rather than direct (see following pages).

"nuclear engineering." As a first step in this direction, in 1946 a training program in nuclear engineering was offered at Clinton Laboratories [the predecessor of Oak Ridge National Laboratory (ORNL)], Oak Ridge, Tennessee — the first formal instruction on this new subject in the United States. The attendees included Hyman G. Rickover.

Although the session at Clinton Laboratories was only a one-shot effort, it suggested to AEC both a need and an alternative for meeting the need. By 1948 AEC was working actively to develop a broad-based program to increase the supply of technical manpower for nuclear energy. In addition to a variety of kinds of university and student support, in 1950 AEC created the Oak Ridge School of Reactor Technology (ORSORT), modeled after the earlier experiment, offering graduate-level training at ORNL in nuclear technology. ORSORT graduated nearly 700 students by 1956, many of whom became key people in the nation's development of nuclear power. As universities reached the point where they could take over the teaching of general nuclear engineering, ORSORT shifted its emphasis to meeting specific needs of the growing nuclear industry in the United States and in other countries. For instance, it trained people in supervising reactor operations and in evaluating reactor hazards, continuing to graduate from 75-80 students per year until it was discontinued in 1965 (because laboratory-based training was no longer needed). Except for the early years, all of the students in ORSORT were AEC employees, employees of AEC contractors, employees of other interested industrial firms in the United States, or equivalent individuals from other countries.

During this same period, training was also provided by other national laboratories and similar centers. An international school was established at Argonne National Laboratory (ANL) in 1955, offering courses in nuclear science and technology for both foreign and domestic students, many from industry. In 1960 it was renamed the International School of Nuclear Science and Engineering, eventually going out of business for the same reason as ORSORT. At Savannah River and several laboratories, courses and seminars were also offered in radiation hazards, handling radioactive materials, and health physics.

In addition to classroom-type training, federal facilities were used to provide practical training and experience in operating nuclear reactors. For example, equipment manufacturers and electric utilities sent people to the National Reactor Testing Station, Idaho, during the 1950s and early 1960s. There, they were given an opportunity to raise a reactor to the critical point and shut it down. Somewhat similar training was offered at Shippingport, Pennsylvania, although the chances to manipulate the controls of an operating reactor were less than at the test reactor in Idaho. Such training was provided at national laboratories as well. Particularly important was the experimental boiling water reactor at ANL, where industrial personnel stayed in residence for as long as two years.

It has been estimated that 1800 people graduated from training courses at national laboratories between 1956 and 1965, the period when the training was focused on industry needs. Many of the graduates went on to teach similar courses in their own firms.

Several general points can be made about this experience.

1. The programs were specific. They never became a large part of the effort of any laboratory or of the federal government's support for nuclear energy. They were small, targeted, and directly related to laboratory facilities and staff expertise.

2. The programs were expedient. They were always seen as a gap-filling temporary activity, a way to meet a national need while universities and firms were developing enough expertise to take over a job that should be theirs in the long run.

3. The programs were flexible. The type and focus of the training shifted as the needs changed during the decade and a half, and it was eventually terminated without great distress.

4. The programs worked. The nation was provided with a core group of trained personnel much more quickly than if such programs had not existed.

In a few cases, laboratories have continued to play a role in training personnel involved in nuclear energy. For example, Brookhaven National Laboratory has been involved in training reactor operators for the Shoreham plant of the Long Island Lighting Company, and several laboratories have offered training in health physics.

Other than in the case of nuclear energy, the direct involvement of national laboratories in training industrial personnel has been very limited, usually consisting of small-scale, temporary instruction that is offered to a wider audience than industry alone. An example is Lawrence Livermore National Laboratory's microcomputer course, now videotaped and being used by industrial firms as well as universities.

### 6.3 Indirect Laboratory Roles

More important on a continuing basis are several indirect national laboratory roles in training industrial R&D personnel: laboratory contributions to student training in universities [such as the roles of Lawrence Berkeley Laboratory (LBL) staff members at the University of California-Berkeley and Pacific Northwest Laboratory's (PNL's) contributions to the Joint Center for Graduate Study in Richland, Washington], laboratory subcontracting which provides opportunities for on-the-job training, laboratory facilities used by industrial personnel, informal contacts with laboratory staff as "mentors," industry participation in laboratory-organized conferences and workshops, laboratory research reports and information services, and national laboratories as a recruiting ground for new industrial managers and technical staff members. Only the last role will be discussed here. (Section 5 deals with other relationships between DOE laboratories and industry/universities.)

One of the ways the nuclear energy industry grew in the United States was by hiring good people from national laboratories (Kuhn 1966). Then and since, laboratories have served as a training ground for mission-oriented research staff and research managers. Transfers from laboratory to industry have been especially important in two kinds of cases: (1) when a high-risk technology being developed in the public sector matures and the effort shifts to the private sector, in which case experts in the laboratories are an attractive source of expertise for firms increasing their role and (2) when a firm is seeking competent middle managers in a high-technology energy R&D area; it turns out that industry's wage levels are often highly competitive at those levels where a mid-career scientist or engineer at a laboratory finds the laboratory's own management pyramid pinching off his/her opportunities for advancement (and the laboratory's salary structure limiting his/her potentials for increases).

This is one training role that has continued since the laboratories disengaged in the mid-1960s from conducting training programs. As the energy laboratories have diversified along with the nation's energy arena, they have seen valued employees — newly trained in growing areas of R&D — move out to manufacturing and consulting firms (and government). In this way (not always happily), in the 1970s the national laboratories have contributed to the training of industrial R&D personnel in fossil energy, conservation, renewable energy, environmental protection, and other fields besides nuclear fission and fusion. As one example, more than thirty engineers and scientists from Sandia's geothermal program have joined industrial firms at industry's initiative.

### 6.4 University Associations

Several laboratories have given rise to associations of universities in their regions, created partly to provide training programs related to laboratory facilities and technical strengths. Such organizations as the Argonne Universities Association, the Associated Universities, Incorporated (Brookhaven), and the Oak Ridge Associated Universities (ORAU) sometimes utilize laboratory staff members, laboratories, and equipment in programs that train personnel for industry.

For example, a "Training and Technology" (TAT) program was initiated by ORAU in 1966, designed to train minority, unemployed, or underemployed individuals for jobs in such fields as industrial welding, machining, and physical testing. Since then, 5000 people have been prepared for entry into the industrial work force, and the job placement rate for graduates of the program has been above 95%. ORAU also offers health physics training to industrial personnel using radioactive materials in R&D; it develops programs to meet specific industry needs, such as developing and implementing a major training program at Goodyear's Gas Centrifuge Enrichment Plant; and it conducts research to anticipate industrial needs for specialized personnel and to alert interested parties to opportunities and gaps.

In most cases, these programs, like the associations which conduct them, operate independently from their neighbor laboratories, but it can be argued that they would not exist — at least in their present form — if the laboratories had not been there as a catalyst for institution-building, and the capabilities of the associations to perform these functions are still related to the resources available at their laboratories.

## 6.5 Possibilities for Enhancing Training Roles

There appear to be three ways that the roles of laboratories in training industrial R&D personnel could be enhanced.

### 6.5.1 Future needs for gap-filling

The direct uses of laboratories in the past have been aimed at specific gaps in manpower training as a new high-technology industry develops rapidly to meet national needs. It is certainly possible that other such needs will appear in the future, especially if a research breakthrough occurs that calls for a new industry. In fact, laboratories are playing a bit of this role now for fusion energy. ANL manages DOE's Fusion Engineering Research Residencies in Industry, an innovative program placing graduate students in industrial firms to work for six months on a fusion project; this program is intended to enlarge the pool of specialists in fusion technology.* And certain cooperative R&D programs, such as the prototype Elmo Bumpy Torus (EBT-P) at ORNL, provide training benefits to the industrial participants as well as R&D support.

### 6.5.2 An expanded role for national laboratories in filling specific gaps in technical manpower

Besides a well-defined training role for a new energy industry, laboratories could undertake more narrowly defined training roles. For instance, technological developments in fields such as materials or instrumentation might call for a series of short courses by laboratories for employees of interested firms, or laboratories might be able to help initiate programs related to such gaps as the developing shortage of skilled technicians for several areas of science and technology, if these needs are not being met by other institutions.

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*ORAU manages DOE's Magnetic Fusion Energy Technology Fellowship Program, which supports Ph.D. candidates in engineering who are preparing for careers in magnetic fusion.

### 6.5.3 An expanded role for laboratory-related university associations in training industrial R&D personnel

Alternatively, these associations could be encouraged to expand their work in identifying training needs and plugging gaps in the nation's system for manpower training, making increased use of laboratory resources as appropriate. As organizations representing universities themselves, they are in a good position to assure that laboratory-focused programs do not duplicate university capabilities.

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# 7. LEGAL MANDATES AND CONSTRAINTS ON THE NATIONAL LABORATORIES*

B. Y. Wilkes and A. C. Zerby

## 7.1 Introduction

In assessing what the roles of the national laboratories should be, an understanding of the laboratories' legal mandates and constraints is needed. The purpose of this section is to define these legal requirements by examining existing laws, Department of Energy (DOE) orders and regulations, and DOE-laboratory contracts.† In addition, attention will be drawn to pending legislation and contemplated DOE and Office of Management and Budget (OMB) policy documents which have the potential for materially affecting the roles of the national laboratories.

The focus of this analysis is on the legally-defined relationship between the laboratories, DOE, and other research sectors, particularly industry and universities. The first part of this section provides some general information on the legal documents pertaining to the national laboratories. The following four sections analyze and summarize what these documents specify about the scope of the laboratories; non-DOE work in general; and the laboratories' relationship with industry and universities, including a discussion on patents and proprietary data, technology transfer, and user facilities.

## 7.2 Legal Documents Affecting the National Laboratories

### 7.2.1 Legislation

In this section, the major pieces of legislation affecting the laboratories were examined, including the legislation that established the Atomic Energy Commission (AEC), the Energy Research and Development Administration (ERDA), and DOE; patent laws; the Economic Recovery Tax Act of 1981; and the Energy Security Act.

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*The authors in preparing this paper have made an extensive review of the applicable laws, DOE orders, regulations and the various DOE contracts, in an effort to assess the legal mandates and constraints on National Laboratories. It should be understood that the paper was purposely prepared from an administrative point of view and was not reviewed for legal sufficiency. The opinions and conclusions expressed in the paper are not those of the Department of Energy or Union Carbide Corporation, but are the opinions of the authors for the purpose set forth in the introduction of this paper.

†A DOE-laboratory contract is the laboratory's prime contract between its managing organization and DOE.

### 7.2.2 Regulations and policy documents

The actual implementation of these laws and administration policy is accomplished through DOE and federal regulations and other policy documents, such as the *DOE Manual*, DOE Orders, DOE Directives, and official correspondence. The *DOE Manual* is a holdover from the *AEC Manual*, which was a comprehensive set of detailed policy statements to guide the Commission's and its laboratories' activities. When ERDA was established in 1974, this agency kept the *Manual* and tried to update sections to reflect newly passed legislation. (The updating process, which is impeded by frequent personnel and organizational changes, can take several years.) When DOE was formed out of various federal agencies, it decided to start from scratch on a new set of DOE Orders to replace the *Manual*. Consequently, the *Manual* was canceled, but most of it had to be retained at the laboratories for reference until DOE Orders were promulgated to replace all of the *Manual*.* DOE also puts out Interim Management Directives that provide some guidance on new legislative changes until a final DOE Order can be approved or an existing one updated. As it now stands, the laboratories use parts of the old *Manual*, the DOE Orders that have been finalized, or interim directives, as appropriate. Out-of-date sections in the *Manual* that have not been replaced may make it more difficult for the laboratories to implement recent legislation.

The laboratories receive DOE's policy documents through their Operations Offices which can add their own policy guidance to suit what is judged to be the individual needs or circumstances of each laboratory. Consequently, the laboratories do not necessarily get identical policy guidance on the same subject,† and they do not always receive DOE Headquarters' policy documents at the same time.

### 7.2.3 Prime contracts

The laboratories' prime contracts with DOE also provide some insights on the legal mandates and contraints on the laboratories. A large proportion of these contracts consists of standard "boilerplate," reflecting DOE and other federal regulations, and is basically identical in each of the contracts. For example, the patent clauses, the Equal Opportunity Employment clauses, the sections on small businesses, and the cost principles are essentially the same. The differences found in the contracts stem largely from differences between the laboratories, such as differences in the type of contractor (university, industry, or

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*When a DOE Order is issued in its final form, it supersedes the part of the *Manual* covering the same topic as the new Order.

†For example, draft ALO Order AL 4300 (which is still subject to revisions) concerning reimbursable work performed by GOCO facilities under the cognizance of the Albuquerque Operations Office is more restrictive than DOE Order 4300.2 from DOE Headquarters (Rodgers et al. 1982).

nonprofit organization); in the physical arrangement [e.g., Battelle owns some of Pacific Northwest Laboratory's (PNL's) facilities]; in the number of parties involved (e.g., Argonne has a three-party contract); and in the scope of work (project-oriented vs multipurpose). Some of the differences may allow individual laboratories to do more than others.

Battelle may use its private facilities, and government owned property in its custody, to perform research and development (R&D) activities for its own account. A "Use Permit," separate from their prime contract, outlines this agreement. This allows industry and universities to have easy access to PNL's facilities and gives PNL the ability to access other research sectors through private research.

Argonne National Laboratory's (ANL's) contract has a "Freedom of Publication" clause. This allows investigators to have full freedom to publish the results of unclassified basic research work conducted under the contract. The purpose of the "Freedom of Publication" clause is to promote scientific progress and technical development.

The contracts for the laboratories operated by the University of California specify five areas of "mutuality," in which both DOE and the contractor must agree. These areas are stated as follows:

1. Procedures for the presentation of work programs shall be jointly developed;
2. The system of accounts shall be changed only as mutually agreed;
3. The property management system shall be mutually approved;
4. Written procurement procedures, consistent with DOE policies and acceptable to both parties, shall be maintained; and
5. Expenditures in connection with personnel may be modified as mutually agreed.

These mutuality statements purportedly give the University of California greater flexibility than other contractors when interacting with DOE.

The laboratory contracts operate under a five-year term and are only updated to reflect new laws and regulations, new agreements between the parties, or to renew the contract. Very little is usually changed in the contracts.

## 7.3 Scope of Work

### 7.3.1 Legislation

The scope of the laboratories' work has evolved along with the scope of their parent agencies — AEC, ERDA, and DOE. Looking first at major legislation, Sects. 3b and 12(a)(5) of the Atomic Energy Act of 1946 (and, later, Sects. 32 and 161e of the Atomic Energy Act of 1954) authorized and directed AEC to conduct nuclear research at the laboratories. In 1967 the 1954 Act was amended to permit the laboratories to perform environmental R&D (Sects. 31 and 32). Four years later this same Act was again amended to expand the scope of the laboratories' work into nonnuclear energy research "... to meet the Nation's energy needs" (Sects. 31, 32, and 33). Although the laboratories' role in nuclear energy R&D was maintained, subsequent legislation broadened ERDA's and DOE's R&D energy mission, leading to an increased emphasis on nonnuclear research, development, and demonstration at the laboratories (e.g., the Federal Energy Administration Act of 1974, the Energy Reorganization Act of 1974, the Federal Nonnuclear Energy Research and Development Act of 1974, and the Department of Energy Organization Act). In addition to energy and environmental R&D, the statutory scope of the national laboratories includes health and safety research. Section 33 of the 1954 Act, as amended, permits the laboratories to perform research and development or training activities and studies in the "fields of protection of public health and safety."

Another recent piece of legislation, the Energy Security Act (Sects. 701-706), specifically involves four of the national laboratories [ANL, Brookhaven (BNL), Oak Ridge National Laboratory (ORNL), and PNL] in an Acid Precipitation Task Force. According to this law, the laboratories are to help formulate a research plan on acid rain and to manage "the technical aspects of Federal acid precipitation research and development programs." Not only does this law presume the laboratories' capabilities in environmental R&D, but it also reinforces the laboratories in roles other than the traditional research role. Through this act, these laboratories are called upon to be both planners and program managers of the federal acid rain research program.

### 7.3.2 Policy documents

Although the legislative definition of the scope of the national laboratories is quite broad, DOE has established policy guidelines, in part, to define the laboratories' research roles as they relate to the roles of industries and universities. The DOE Order that establishes the institutional planning process for the laboratories (DOE Order 5000.1) outlines the work that is appropriate for the multiprogram laboratories (MPLs) (vis-a-vis university or industry sectors); that is, work that "requires use of skills or facilities uniquely available at the laboratories, or is determined not to be within the capability and interest of university or industry to perform, or requires a fast startup or multidisciplinary approach not readily available to the private sector to meet an urgent national research and developmental need."

A DOE memorandum from Guy W. Fiske, Under Secretary, (May 5, 1982) provides more detailed guidance on the MPLs' missions and goals. The stated missions include R&D in defense, nuclear and nonnuclear energy, high energy physics, basic research, and energy-related life and environmental sciences; contributions to maintaining the national security considering both our defense and economic strengths; contributions to the technology base (in cooperation with universities and industry) which provides an increased capability to foster enhanced productivity and innovation; and activities that are an integral part of our country's leadership position in critical areas of science and technology. Among other goals, the laboratories are to "perform research and development on long-term, high-risk, high-payoff energy technologies beyond the development horizon of the private sector" and to "perform research and development in areas where industry and, where relevant, universities would have an apparent or actual conflict of interest."

Another DOE policy document, DOE Order 5600.1, provides some guidance to DOE's weapons facilities on the use of the weapons complex for nondefense activities: "The utilization of the capabilities of the weapon complex in support of DOE's nonweapon responsibilities or other programs of national interest is encouraged but limited to the extent that such utilization does not adversely impact the weapon program."

A proposed OMB policy *(Fed. Regist.,* December 31, 1980) would have limited the use of the national laboratories. The proposed policy set forth guidelines on the use, periodic review, and termination of federally funded research and development centers (FFRDCs). The policy directed agencies to "carefully consider alternatives for meeting their special technical needs before using an existing FFRDC." This proposed OMB policy is currently being redrafted.

### 7.3.3 Prime contracts

Statements in the contracts dealing with the scope of the multiprogram laboratories are very broad. There is also quite a variation in the amount of wording given to this subject in the contracts. The wording ranges from ORNL's contract, which contains very little on the scope of the work to be performed at the laboratory, to ANL's contract which describes their basic research work, applied R&D work, and their role in the development of energy technology.

One reason for the broad language is to allow either party to have some latitude in determining the work to be performed. The contracts, in this respect, act as a charter to further the working relationship between the contractors and DOE. However, the programs undertaken at the laboratories must be in accordance with the policies of DOE. DOE is responsible for the conduct of its program which requires it have the power to exercise general control over the contract work. Close collaboration usually occurs between the contractors and DOE in formulating the work program of their laboratory.

### 7.3.4 Conclusions

Under U.S. laws and the laboratories' operating contracts, the potential scope of the laboratories is quite broad, encompassing health and safety research and all areas of nuclear and nonnuclear energy and environmental research and development. DOE policies, however, have set limits on what is considered as appropriate work for the laboratories.

## 7.4 Non-DOE Work

In this section, non-DOE work in general and, particularly, work for other federal, state, or local agencies is examined. The laboratories' relationship between industry and universities is studied in the next section (7.5).

### 7.4.1 Legislation

The national laboratories and DOE have benefited from the work the laboratories have done for other government agencies. Non-DOE work has often developed or maintained expertise in areas that DOE has needed. The Atomic Energy Act (Sect. 33) authorized AEC (and, later, DOE) to conduct research for others "through its own facilities." The Act limited the non-DOE effort to energy R&D and work in public health and safety fields that the agency deemed appropriate. This law also specifies that before DOE undertakes work for others, it must first determine whether any private facilities or laboratories are available to do the work. The Department of Energy Organization Act [Sect. 649(*b*)] authorizes DOE to permit the use of its facilities by public and private agencies, corporations, associations, or other organizations or by individuals.

More generally, the Economy Act of 1932 (Sect. 686) permits any agency to do work requested by another agency as long as (1) there is no private source that is as convenient and as inexpensive as the performing agency and (2) the work can be done by using existing staff and facility capabilities; most agencies are prohibited from subcontracting another agencies' work. A bill (H.R. 2528) has been proposed in the U.S. House of Representatives that would amend the Economy Act to allow all federal government departments and agencies to obtain materials or services from other agencies by contract (*Congressional Record-House*, March 23, 1982).

The requesting agencies also have specific statutory authority to request the work from DOE. For example, the Energy Reorganization Act of 1974 authorized the Administrator of ERDA (and, later, DOE) to "furnish to the [Nuclear Regulatory] Commission, on a reimbursable basis, through their own facilities ... such research services as the Commission deems necessary ... ; and ... physical access to its facilities ..." [Section 205(c)]. From this law the national laboratories are *required* to perform research for the Nuclear Regulatory Commission (NRC) and to allow NRC to use its facilities. The statutory authority of other requesting agencies is not stated as strongly as NRC's authority, but a degree of obligation by DOE may be implied. Examples of authority in other agency statutes are: 42 U.S.C. §1870(c) and (j) for the National Science Foundation (NSF); 42 U.S.C. §1959c., 1959d. for the Secretary of the Interior in water research and development; and 42 U.S.C. §254 for the National Institutes of Health.

An important though much smaller proportion of the laboratories' non-DOE effort has been for state and local governments. The Intergovernmental Cooperation Act of 1968 (Title III) authorizes federal agencies to provide specialized or technical services to state and local units of government. OMB Circular A-97 specifies the rules and regulations to be followed under this Act.

### 7.4.2 Policy documents

For non-DOE work for other federal agencies and state and local governments, the laboratories were, until recently, following the guidance contained in the *AEC Manual* Chapter 0214, dated November 22, 1974. This manual chapter has been replaced by DOE Order 4300.2, which was issued from Headquarters to the Operations Offices, October 8, 1981. However, at least one of the laboratories is still waiting (as of September 1982) to receive this Order and additional related guidance from their Operations Office. This new DOE order covers R&D work performed for any non-DOE group or person by government-owned, contractor-operated facilities. Both the canceled *AEC Manual* Chapter 0214 and the new DOE Order 4300.2 specify certain restrictions on the laboratories' non-DOE work: (1) it must be determined that private facilities and laboratories are not available to perform the work on a convenient basis and at a reasonable cost; (2) the non-DOE work will not interfere with DOE program activities; and (3) the work must be consistent with DOE's basic responsibilities. Both documents also state that most work for other federal agencies will be executed through interagency agreements. The canceled *AEC Manual* Chapter MC 0214 expands this further by stating that "laboratories normally do not respond to RFP's" (requests for proposals). The *AEC Manual* also details how the laboratories should "avoid the appearance of competition with private laboratories and industry." "Informal contacts by the laboratories and the AEC with potential sponsors are encouraged," but the laboratories are "cautioned against engaging in activities which could be characterized as promotional."

In addition to DOE policy documents, OMB Circular A-76* details "policies to be followed in acquiring commercial or industrial products and services needed by the government" (including R&D activities). The basic policy is for government to rely on the private sector for these services unless private sources are not available, the services are inherently governmental by nature, or in-house government performance would be more cost-effective. This OMB policy again points out that the national laboratories must determine whether there are convenient and reasonably priced private sources available before undertaking work for others.

Although other agencies have the statutory authority to request work from DOE (as described in the preceding section), the agencies' policies may actually constrain the laboratories from receiving funds. For example, the *National Science Foundation Grant Policy Manual* (201.1d) specifies that: "In carrying out its statutory purposes, NSF is expressly authorized by its own statutory authority to support research performed by other Federal agencies. However, it presently is Foundation policy not to encourage research proposals from other Federal agencies except in pursuit of specific NSF objectives."*

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*According to DOE's Office of Policy Procurement and Assistance Management Directorate, OMB Circular A-76 does not apply to DOE laboratories and GOCOs; however, some of its criteria have been used in making purchasing decisions at the laboratories. Criteria separate and distinct from the criteria in A-76 are now being developed for the laboratories' use (Newman 1982).

### 7.4.3 Prime contracts

Argonne's and Brookhaven's contracts include a clause regarding the performance of non-DOE activities when the use of laboratory equipment, facilities, or personnel is involved. Other laboratory contracts do not have this clause. A detailed written request, submitted to DOE for prior approval, is required to perform outside work. The request includes the nature of the outside work to be performed, the laboratory equipment to be used, the facilities or personnel required, and the financial arrangements proposed to pay for the cost of such work. A major consideration in the approval of such work is that it does not interfere with the current or future needs of DOE's programs. If DOE approves the request, the contractor and DOE then agree on the terms and conditions that would apply to the outside work. Except where the special terms and conditions apply, the articles of the laboratory contract are applicable to the performance of the work.

Although most of the contracts do not have this clause, the contractor is still required to comply with the rules and regulations, as set forth by DOE, with regard to this subject.

### 7.4.4 Conclusions

The national laboratories are permitted, sometimes encouraged, and, in certain cases (NRC), required to do work for other government agencies. Care must be taken to ensure that the laboratories are not competing with the private sector and that the work is appropriate and does not interfere with DOE work. Interagency agreements are set up between DOE and the federal agency requesting the work. According to DOE policy, laboratories are not supposed to respond to RFPs. Other agencies' policies (e.g., NSF) may constrain the laboratories from receiving funds even though these agencies have statutory authority to request work from DOE.

## 7.5 The Laboratories' Relationship with Industry and Universities

Several key issues, which have an impact on the interface between the laboratories and the private sector, are discussed from a legal standpoint in this section (e.g., patents and proprietary data, technology transfer, and private use of DOE facilities).

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*The types of projects that NSF will consider supporting at the laboratories (including multiuser facilities) are described in NSF Circular No. 108.

### 7.5.1 Patents and proprietary data

**7.5.1.1 Legislation.** DOE's "restrictive" patent and data policies have often been cited as a major obstacle in getting the laboratories and industry to work together on joint research projects. At least on paper, DOE's policies in this area may be more liberal than they have been credited to be, and recent DOE policy changes may further improve the situation.

*Patents.* Section 152 of the Atomic Energy Act of 1954 contains DOE's statutory authority on patent rights to nuclear inventions: "Any invention or discovery, useful in the production or utilization of special nuclear material or atomic energy ... shall be vested in, and be the property of, the Commission [DOE], except that the Commission [DOE] may waive its claim to any such invention or discovery under such circumstances as the Commission [DOE] may deem appropriate ...."

The Federal Nonnuclear Energy Research and Development Act of 1974 (Sect. 9) allows DOE to waive its right to take title to nonnuclear inventions made under any contract if such a waiver is in the "best interests of the United States and the general public." According to this 1974 act, DOE's objectives in its determination of patent rights are to (1) make the benefits of energy research, development, and demonstration (RD&D) available to the public quickly; (2) promote commercialization of these inventions; (3) encourage participation in DOE's RD&D program by the private sector; but also (4) foster competition and prevent undue market concentration. This law details several factors for DOE to consider in making its patent decisions, including the following: whether a waiver is needed to secure the participation of a contractor; the contractor's commercial position; the contribution the contractor has made or will make; the purpose of the contract and the intended use of the contract results; the effect of a waiver on public health, safety, and welfare, and on competition; the technology transfer capability of a university; and the small business status of a waiver applicant. Through this Act, DOE is authorized to grant both "advance" waivers at the time a contract is signed, which cover all or part of the inventions made under a contract, and "identified" waivers to individual inventions decided on a case-by-case basis.

But even when DOE waives its patent rights to a contractor or inventor, the government retains certain rights to the inventions, including a royalty-free, worldwide license to each invention* and certain "march-in" rights. These "march-in" rights include the right to require the contractor to license the invention to others under certain conditions and the right to terminate the waiver in whole or in part if the contractor is not, or within a reasonable time will not, take effective steps needed to commercialize the invention. Obviously, these

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*As stated in Sect. 9(h)(2) of Pub. L. 93-577, the government retains "an irrevocable, nonexclusive, paid-up license to make, use, and sell the invention throughout the world by or on behalf of the United States (including any Government agency) and States and domestic municipal governments."

"march-in" rights would discourage industry from risking a joint venture with DOE, but according to DOE, such "march-in" rights have rarely been exercised by the government (Denny 1980).

A little over a year ago Congress passed Public Law (Pub. L.) 96-517 which further liberalized DOE's patent policy. The law allows each nonprofit organization (e.g., universities) or small business to elect to retain title to any invention conceived under a funding agreement with DOE, unless the funding agreement provides otherwise.* The government is still required to retain "march-in" rights very similar to the ones specified in the Federal Nonnuclear Energy Research and Development Act of 1974.

The 97th Congress is now considering additional changes in patent policy which are designed to provide industry with more incentive to commercialize inventions developed with federal funds. Both the House bill (H.R. 4564) and the Senate bill (S. 1657) would permit large companies to retain rights to inventions that are developed with federal dollars, thus giving them the same advantage as universities and small businesses gained from Pub. L. 96-517. Senate bill 1657 would also give the operator of GOCO facilities the option of retaining rights to federally funded inventions made at their facilities (Rodgers et al. 1982). Again, the government would retain certain "march-in" rights under this law.

Although DOE has expressed reservations, the Administration presently favors the provision of S. 1657 allowing GOCO operators the option of retaining title to federally funded inventions made at their facilities. The Director of the Los Alamos National Laboratory (LANL) has strongly endorsed this provision of S. 1657 because he believes that it will provide an added source of income to support discretionary research at LANL's facilities and will at the same time provide the Laboratory a greater flexibility in dealing with industry (Rodgers et al. 1982). DOE General Counsel does not agree that the laboratories would necessarily benefit from S. 1657 because the patent rights would go to the GOCO operators, not to the laboratories themselves (Denny 1982). If S. 1657 is enacted into law, it will produce significant changes in the DOE patent policies.

*Proprietary data.* Another concern of industry in working with the laboratories has been DOE's statutory responsibility to disseminate information gained from its research programs. Industries need to be assured that their proprietary data can be kept secure. According to the Atomic Energy Act of 1954 (Sect. 141b), "the dissemination of scientific and technical information relating to atomic energy should be permitted and encouraged... ." Likewise, the Energy Reorganization Act of 1974 authorized ERDA (now DOE) to disseminate "scientific, technical, and practical information relating to energy so as to enlarge the fund of such information and to provide that free interchange of ideas and criticism which is essential to scientific and industrial progress and public understanding." Although the laboratories have a duty to disseminate information and data developed at their facilities, they are in no way required to disseminate and publish industries' proprietary data.*

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*The funding agreement may provide otherwise if (a) it is for the operation of a GOCO facility, (b) DOE determines that there are exceptional circumstances wherein restriction or elimination of the right to obtain title would better promote the purposes of the law, and (c) an appropriate government authority determines that restriction or elimination of the right to obtain title is necessary to protect the security of foreign intelligence or counterintelligence activities (Rodgers et al. 1982).

7.5.1.2 **Regulations and policy documents.** The following sections examine how DOE has responded — through its regulations and policy documents — to the legislation Congress has enacted on patents and proprietary data.

*Patents.* Although the Federal Nonnuclear Energy Research and Development Act (Pub. L. 93-438) permitted ERDA (DOE) to grant patent waivers in 1974, DOE's patent regulations implementing this act were not published until 1979 (DOE June 30, 1979). In the interim, ERDA promulgated a temporary regulation, ERDA-PR Temporary Regulation No. 9, on April 14, 1975, to provide temporary instructions to implement the patent contracting and waiver policies set forth in Sect. 152 of the Atomic Energy Act of 1954 and Sect. 9 of Pub. L. 93-438.

To facilitate implementation of Pub. L. 96-517, which gave small businesses and universities patent rights to inventions conceived under contract to DOE, DOE's Acting Director of the Office of Policy Procurement and Assistance Management distributed OMB Bulletin 81-22 and a revised DOE Patent Rights Clause to be used in these cases. The OMB Bulletin entitled, *Patents - Small Business Firms and Non-Profit Organizations* provides interim policies, procedures, and guidelines on inventions made by small businesses and nonprofit groups under funding agreements with federal agencies. These OMB guidelines took effect as of July 1, 1981, but the policy was open for public comment. A final OMB Circular (OMB Circular A-124) was issued February 19, 1982.

A class waiver for industries or other organizations that are paying the full costs of any work done at the laboratories has recently (June 29, 1982) been finalized. Under this class waiver, a third party, which has been approved to use the laboratories' facilities on a full-cost recovery basis, can acquire patent rights as long as the work does not overlap with mission-oriented work (Denny 1982). This class waiver should be an added incentive for the private sector to make use of unique resources and expertise available at the laboratories.

*Proprietary data.* DOE's technical data policy, as stated in the Procurement Regulations, Subpart 9-9.2, is aimed at making the benefits of RD&D known, promoting commercialization, fostering competition, but also encouraging the private sector's participation in DOE research programs. In light of the last objective, DOE's procurement regulations do provide for procedures to keep an industry's proprietary data secure. The Rights to Technical Data (long form) Clause of §9-9.203-3(e)(2), to be included in a contract with industry, allows a firm to withhold its proprietary data. The clause does give DOE "inspection rights," by which the agency can inspect the data to verify that the data is, indeed, proprietary or to evaluate work performance. An optional clause can also be added which would give DOE other limited rights in proprietary data when such data are needed for programmatic reasons. Three circumstances are specified in this "Limited Rights Legend": (1) proprietary data may be disclosed for evaluation purposes; (2) proprietary data may be disclosed to other contractors participating in the same DOE program; and (3) proprietary data may be used for emergency repair or overhaul work but kept in confidence and not disclosed any further.

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*Disclosure of any information which concerns or is related to trade secrets, processes, operations, or apparatus is prohibited by 18 U.S.C. 1905 (Newman 1982).

7.5.1.3 **Prime contracts.** All of the multiprogram laboratory contracts, except for Sandia National Laboratories' (SNL's) contract,* contain similar statements in reference to patents and proprietary data. The statements stem from DOE procurement regulations as set forth in 41 CFR, Part 9-9. Clauses appearing in the contracts in reference to this topic include "Authorization and Consent," "Notice and Assistance Regarding Patent and Copyright Infringement," "Reporting of Royalties," "Patent Rights," and "Rights in Technical Data."

Proprietary data is recorded information of a scientific or technical nature which embodies trade secrets. An irrevocable, nonexclusive license and right to use proprietary data is granted to the government when the proprietary data is used in the performance of the contract. However, if the proprietary data is specifically identified by the contractor at the time of initial delivery to the government, the proprietary data may not be disclosed outside the government without prior permission of the contractor (as set forth in the "Limited Rights Legend" of the contract).

Under "Patent Rights," the contractor agrees to assign the entire right, title, and interest of each invention or discovery to the government except to the extent that a license or waiver is retained by the contractor. Waviers, including advance waivers, are requested by the employee-inventor or the contractor in accordance with DOE procurement regulation 41 CFR 9.9-109.6.

7.5.1.4 **Conclusions.** The basic patent and data policy set forth for DOE by Congress in for the government to take title to all inventions and to disseminate publicly information gained from DOE's R&D programs. But to encourage industrial participation in DOE's research programs and early commercialization, some flexibility has been built into DOE's statutory authority and regulations: patent waivers can be granted, and proprietary data can be kept secure. It is difficult to determine whether these policies in actual practice are sufficiently flexible to build a strong R&D partnership between DOE (and its laboratories) and the private sector. According to James E. Denny, Assistant General Counsel for Patents, it is impossible to precisely identify how many patent waiver requests have been made and granted because waivers are made through a negotiation process. A critical factor in this negotiation process is the time it takes. DOE's patent counsel admits that "the whole waiver process is a substantial, time-consuming administrative burden for both DOE and its prospective and actual contractors" (Denny 1980). If it takes too long to get a patent waiver granted or a company's proprietary data rights negotiated in a contract, it may not be worth the effort for an industry to deal with DOE and its laboratories. A few successes can be reported in this area. In the last couple of years, ORNL and other laboratories have been able to set up proprietary research contracts with a few industries.* The negotiation process for these contracts often takes a year or more. According to DOE's patent office, at least two patent waivers have been granted to industries doing work with the national laboratories, one involving BNL and one involving LLNL (Raubitschek 1982). Maybe these few instances are, at least, a beginning, but the negotiation process obviously needs to be streamlined if substantial progress is to be made in this area. The recent class waiver for fully reimbursed work will go a long way in streamlining DOE's patent waiver process. Additionally, laboratory/industry interaction could be considerably improved if DOE established a policy of granting exclusive rights to DOE inventions in return for the industry investment required to commercialize them.

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*Western's contract with DOE for SNL is different. All rights and information on inventions or discoveries are furnished to DOE for their exclusive use except that a royalty-free license in retained by Western Electric Company for public service communications equipment.

## 7.6 Technology Transfer

### 7.6.1 Legislation

The Stevenson-Wydler Technology Innovation Act of 1980 is aimed at promoting U.S. "technological innovation for the achievement of national economic, environmental, and social goals." The law is intended to stimulate "improved utilization of federally funded technology developments by State and local governments and the private sector" and also to encourage "the exchange of scientific and technical personnel among academia, industry, and Federal laboratories." One mechanism to fulfill these objectives is the establishment of an Office of Research and Technology Applications within each federal laboratory. The staffing and funding levels for these offices is to be determined by the laboratory and its parent agency, but each laboratory having a budget exceeding $20 million is to have at least one professional staff person in these offices. Also, at least 0.5% of the agency's R&D funds is to be used for technology transfer at the agency and at the laboratories; part of this money is to go toward the support of the Offices of Research and Technology Applications.

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*For example, both DuPont and Firestone negotiated contracts to use a user facility at ORNL, the National Center for Small-Angle Scattering Research, for proprietary work.

Most of the national laboratories already had technology transfer offices with functions similar to those outlined in the law for the Offices of Research and Technology Applications, [i.e., (1) preparing an application assessment of each R&D project with potentials for application in state or local government or in industry; (2) providing and disseminating information on federally owned or originated products, processes, and services; (3) cooperating with and assisting the Center for the Utilization of Federal Technology (also established by this law) and other such organizations; and (4) providing technical assistance in response to requests from state and local government officials].

On July 22, 1982, another technology transfer act, the Small Business Innovation Development Act of 1982 (Pub. L. 97-219), was enacted into law. This new act requires federal agencies with substantial R&D budgets to establish small business innovation research programs designed to facilitate small business participation in federal R&D and to foster technological innovation.

### 7.6.2 Policy documents

DOE's technology transfer policy is established in DOE Order 5800.1, "Research and Development Laboratory Technology Transfer Program," issued from Headquarters on March 25, 1982.* This order requires the laboratories to conduct technology transfer activities, including: (1) the "assessment of R&D projects for applicability to the needs of the private sector and State and local governments; (2) application and/or adaption of research or technology into processes, products, and services for use by private sector and State and local governments; (3) technical assessment to the private sector and State and local governments in adapting federally developed technology for use; (4) cooperation with technology transfer brokers to move technology from the laboratories to the private sector and State and local governments; and (5) licensing of DOE-owned patent technology for commercial use." Each laboratory is required to formulate an annual 5-year technology transfer program plan and an annual technology transfer program report.

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*As of July 1982, two of the multiprogram laboratories had not received their official copy of DOE Order 5800.1 from their Operations Offices.

### 7.6.3 Prime contracts

There are not specific clauses in the contracts that deal with technology transfer. There are, however, statements that describe interactions between the Contractor and other research sectors in ANL's and PNL's contracts. Other contracts contain little or nothing with regard to technology transfer issues.

ANL's contract has sections that describe their cooperation with Research and Educational Institutions and Industrial Organizations and that determine their responsibilities in this regard. ANL's program of cooperation with the academic community is set up to promote research and education in fields of interest to DOE and to facilitate interrelationships with academia. Joint experimental programs and an interchange of faculty and staff are part of this effort. Cooperation with Industrial Organizations include an early transfer of information to industry, active participation by industry representatives in laboratory programs, and an optimum use of industry for design, fabrication, and construction. Laboratory facilities may be made available to industry with the agreement of ANL and DOE.

PNL's contract mentions cooperative educational programs with universities and colleges by the utilization of laboratory staff and facilities. In addition, PNL shall cooperate with industry to assist in increasing the contribution of industry to applications of energy related science and technology. This cooperation may include an early transfer of information to industry.

### 7.6.4 Conclusions

It is too early to tell whether the Stevenson-Wydler Act will significantly increase technology transfer between the national laboratories and other sectors. At a minimum, the Act forces the government and its laboratories to put a high priority on technology transfer activities. But perhaps some other actions would address some real problems in the technology transfer process; such actions might include (1) further stream lining DOE's complex and lengthy patent and proprietary data policies and (2) providing the laboratories with monetary incentives in the technology transfer process. One way to provide monetary incentives would be to allow the operators of the laboratories to license the products or processes developed at the laboratories for the benefit of the laboratories. The revenue gained from granting the licenses and from royalties could be used by the laboratories as a discretionary fund (e.g., to support exploratory projects). This process would motivate the laboratories to transfer its technologies and help ensure that industry commercialized them.

## 7.7 Other Issues

### 7.7.1 User facilities

A primary role of the national laboratories is to act as stewards of large R&D facilities to be used by researchers from all sectors. Both the Atomic Energy Act of 1954 (Sects. 31, 32, and 33) and the Department of Energy Organization Act [(Sect. 649(b)] permit other government or private organizations or individuals to use DOE's facilities.

The canceled *AEC Manual* Chapter 7603, "Use of AEC Facilities and Equipment for Private Purposes" (December 6, 1974) put two constraints on private use of DOE's facilities: the use must not interfere with AEC work and it must be determined that adequate commercial facilities are not reasonably available. This *AEC Manual* Chapter has been replaced by DOE Order 4300.2 at some of the laboratories*; 4300.2 specifies similar stipulations on the use of DOE facilities. One important difference between *AEC Manual* 7603 and DOE Order 4300.2 is in the treatment of patents. *AEC Manual* 7603 states that "the Commission [DOE] shall have the sole power ... to determine the disposition of the title to and the rights under any application or patent that may result." DOE Order 4300.2 specifies that "patent and data rights are negotiated for every R&D work for others request," and "in certain cases, DOE Patent Counsel will waive, in advance, the Government's rights in inventions...."

A DOE memorandum (October 1979) from James S. Kane, Associate Director for Basic Energy Sciences in DOE's Office of Energy Research, spelled out the agency's proposed guidance on user charge† and proprietary use of user facilities. Basically, the proposed policy stipulated that a user who would agree to publish the results and who performed research that was of programmatic interest to DOE, would not be charged for the use of the facility. A user who performed proprietary research would be assessed on a full-cost recovery basis. Patent waivers could be requested by any user. Proprietary users, paying full cost, would probably be granted patent waivers, if requested.

A finalized DOE policy on user facilities (including the operations offices' policy guidance) would help the laboratories expedite the contracts needed for industry and others to use these facilities. DOE Order 4300.2 was in a draft/review stage for close to a year and a half before it was issued in October 1981; one of the laboratories has still not received this order (as of September 1982).

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*At least one of the laboratories has not yet received DOE Order 4300.2 (as of September 1982) along with additional guidance from the Operations Office.

†The official pricing policy for DOE laboratories' work-for-others is provided in DOE Regulation 10 CFR 1009.

### 7.7.2 Economic Recovery Tax Act of 1981

Under Subtitle C, this act provides industry with some tax incentives to perform R&D. But for the R&D to qualify, it cannot be conducted at federal facilities (Wood 1981). With this exclusion, universities and nonfederal laboratories are given an advantage over the national laboratories in doing contract research with industry.

## 7.8 Possible Changes in Legislation and Other Rules Affecting Multiprogram Laboratories

Any suggested changes in the legal documents affecting the multiprogram laboratories should be based on the recommendations of the Panel for modified laboratory roles. We think it likely that very few changes in the formal, written rules will need to be suggested; the current laws and regulations appear to offer a great deal of latitude for interpretation and policy guidance. DOE, or its successor agency, may be able to carry out many of the recommendations of the Panel by modifying its governing manual (e.g., DOE Orders). The contracts between DOE and the operating contractors represent another vehicle for mandating desired institutional changes.

The legislation which defines the laboratory roles places very few constraints on DOE's authority to modify laboratory roles. Perhaps the only serious legislative barrier to change in a particular direction is the Economic Recovery Tax Act of 1981, if it were desired to encourage industrial contract work at the labs.

In considering any possible legislative, regulatory, or policy changes, emphasis should be placed on the possible need for changes in rules related to (1) relationships of laboratories to DOE and other federal agencies; (2) the transfer of technologies, information, and experience from laboratories to meet external needs; and (3) relationships of laboratories with industry, apart from technology transfer.

### 7.8.1 Relationships with DOE and other federal agencies

To equip DOE for a period of decline in federal energy R&D budgets, it is conceivable that some modifications may be needed in the rules affecting MPLs, especially those dealing with:

1. definitions of the scope and mission of laboratories,
2. policies on work-for-others,
3. support for in-house discretionary R&D,
4. policies on inventions by laboratory staff members, and
5. good ideas in some prime contracts for MPLs that might be added to others.

### 7.8.2 Transfer of technologies, information, and experience

The Stevenson-Wydler Technology Innovation Act of 1980 specifies a role for federal laboratories, adding to the general sense that laboratories should seek to be more effective in transferring their products, knowledge, and experience to industry, universities, state and local governments, and other potential users in American society. Although policy documents and other guidelines have encouraged this kind of activity in the past, it is possible that certain changes will be needed to respond to the expectations of the 1980s. It is important to continue to examine

1. rules and policies related to compliance with the Stevenson-Wydler Act, and
2. other rules related to arrangements for sharing laboratory people and expertise with external groups.

### 7.8.3 Relationships with industry

It is frequently suggested that a stronger collaboration between DOE national laboratories and private industry is in the national interest. If so, we should concentrate on

1. patent policies — how they are stated formally, how they are implemented, and how well industry is informed of these policies;
2. policies regarding proprietary data;
3. policies regarding work by laboratory staff on contract to industry; and
4. the significance for laboratories of recent legislation intended to encourage innovation in industry:
   (a) the Economic Recovery Tax Act of 1981, which excludes contract work conducted at national laboratories from the tax incentives offered for private-sector R&D investment; and
   (b) the Small Business Innovation Research Act of 1981, which will require laboratories to assist small businesses in being more innovative technologically.

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# APPENDIX A

# FACTS ABOUT HARWELL, CEN-SACLAY, TNO, STUDSVIK, AND JAERI-TOKAI

E. L. Preston and C. D. West

## A.1 Harwell

Location — Oxfordshire, England

Director — L. E. J. Roberts, CBE

Parent organization — United Kingdom Atomic Energy Authority (UKAEA)

Date established — 1946

Staff — 4300 of whom 850 are scientists and 350 are engineers

Annual budget — 1980-1981: £72 million (at 1980 values)
(about $125 million)

Functional management — Matrix management

Research divisions — Chemical Technology
Chemistry
Computer Science and Systems
Energy Technology Engineering Design and Manufacture
Engineering Projects
Engineering Sciences
Environmental and Medical Sciences
Instrumentation and Applied Physics
Marine and Engineering Services
Materials Development
Materials Physics
Metallurgy
Nuclear Physics
Research Reactors
Theoretical Physics

In 1946 the Atomic Energy Research Establishment at Harwell was established to undertake R&D on all aspects of atomic energy. The Laboratory became part of the newly formed UKAEA in 1954. Nuclear power development is still the largest single program at Harwell; however, as a result of the Science and Technology Act (1965), which allowed UKAEA to diversify its R&D efforts into nonnuclear fields, Harwell today conducts research in physical and engineering sciences and, to a rather limited extent, the biological sciences as well.

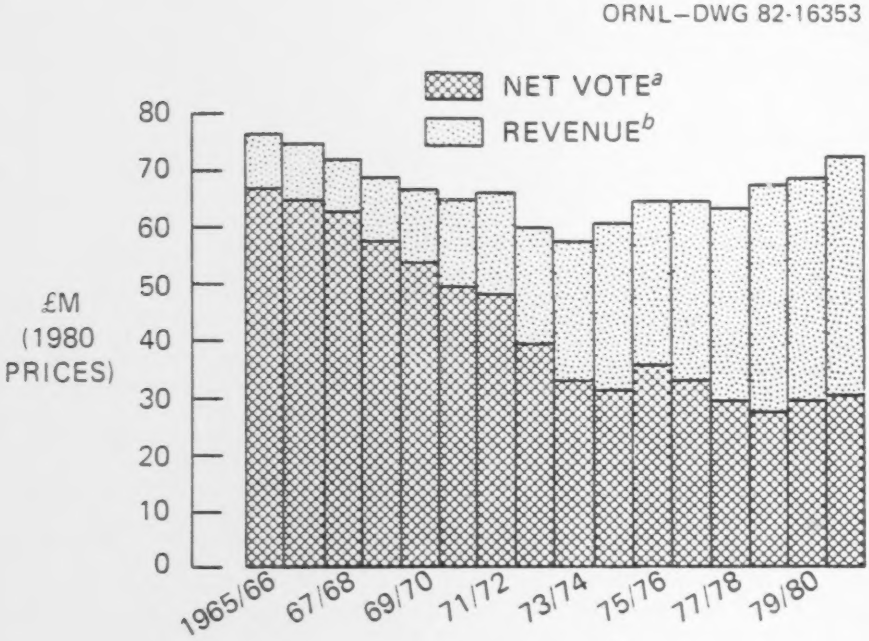
Three important principles of operation were mandated by the Science and Technology Act.

1. The UKAEA should seek to widen the market for Harwell's existing skills rather than widen their range of skills.

2. They must tie the work to a customer and find users in advance for their new work rather than operate on a "missionary" basis, seeking applications for work after it has been done.

3. They should act in as commercial a manner as possible consistent with the national interest.

Harwell is now the largest contract research organization in Europe, earning more than half of its budget requirements from non-UKAEA sponsors (Fig. A.1), most of its customers being other government departments and agencies (Fig. A.2). However, in 1979-1980 Harwell also worked for about 1000 commercial customers, including large national companies, public-sector industries, and small firms. Industrial firms have proprietary rights to work they fund at the Laboratory, an essential element in Harwell's ability to serve industry. Commercial programs include computer technology, environmental sciences, offshore technology, instrumentation, and some work on biotechnology. The breadth of Harwell's work, and its multidisciplinary nature, is indicated by the range of disciplines represented by its divisions. Harwell is located in Oxfordshire, England, at a site originally chosen partly for its proximity to the major academic centers provided by Oxford University. The Laboratory has a staff of 4300 of whom 850 are scientists and 350 are engineers. The distribution of the staff among the research programs is given in Table A.1, and, on a broader scale, in Fig. A.3 which also gives a perspective on the changes brought about by the diversification program. When the diversification program began, Harwell adopted a matrix form of management for its applied programs to replace its traditional, discipline-oriented line management. In 1980 31% of the funds came from government agencies other than UKAEA, 12% from the United Kingdom's nuclear industry, 10% from other British industry (including nationalized industries), and 5% from overseas customers; and about 1% of the budget was in the form of license and royalty earnings.



[a] MONEY APPROPRIATED BY PARLIAMENT FOR HARWELL'S FEDERAL NUCLEAR ENERGY RESEARCH PROGRAMS.

[b] MONEY PAID TO HARWELL FROM OTHER SOURCES FOR CONTRACT R&D AND SERVICES.

Fig. A.1. Harwell revenue and vote funding 1965-1981. Source: United Kingdom Atomic Energy Authority, 1981.

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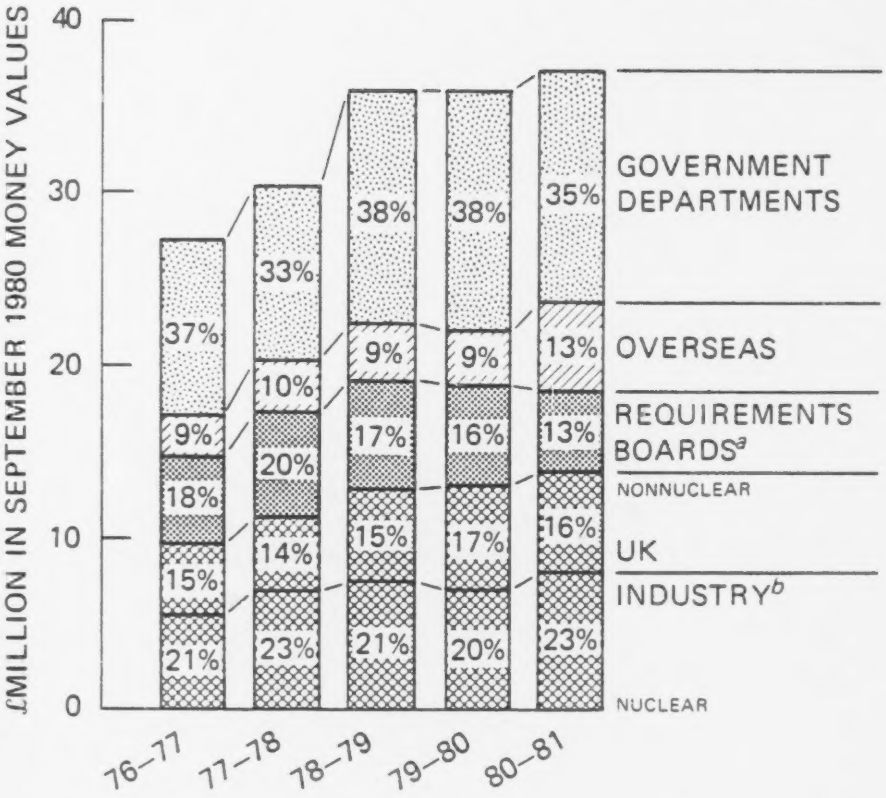

[a]BASICALLY, THESE ARE GOVERNMENT RESEARCH FUNDS DISBURSED BY BOARDS COMPOSED MAINLY OF INDUSTRIAL REPRESENTATIVES.

[b]THIS CATEGORY INCLUDES NATIONALIZED INDUSTRIES.

Fig. A.2. Harwell sources of R&D revenue income 1976-1981 (excludes the federal nuclear energy research programs). Source: United Kingdom Atomic Energy Authority, 1981; Harwell, 1980.

**Table A.1. Harwell staff distribution (1980)**

| Program areas | Professional staff |
|---|---|
| Nuclear power | 385 |
| Underlying research | 215 |
| Plasma and fusion | 20 |
| Nuclear research on repayment | 160 |
| Environmental program | 90 |
| Industrial program | 180 |
| Energy program | 150 |

Source: Harwell Research Laboratory of the United Kingdom Atomic Energy Authority. 1980. United Kingdom Atomic Energy Authority.

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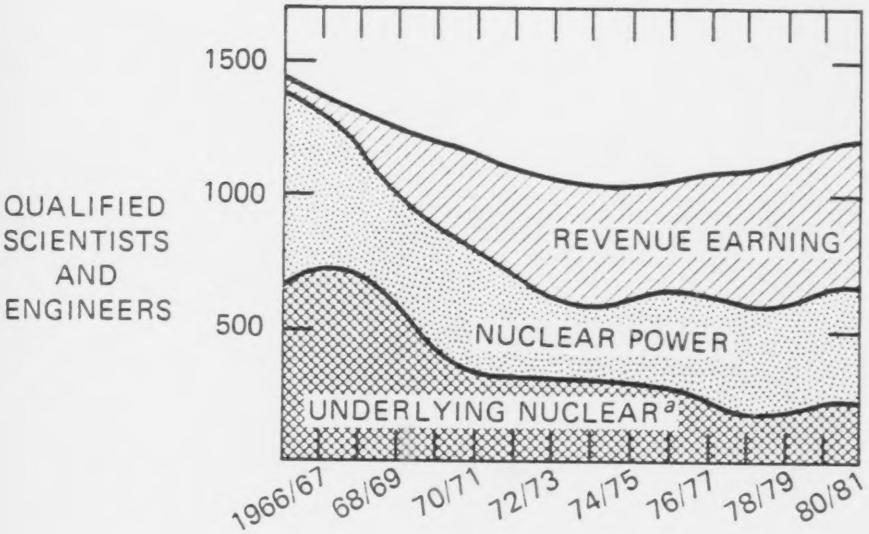


[a]BASIC RESEARCH AND DEVELOPMENT RELATING TO NUCLEAR ENERGY BUT NOT DIRECTED AT A SPECIFIC NUCLEAR PROGRAM OR PROJECT.

Fig. A.3. Deployment of Harwell's professional scientific manpower between programs 1965-1981. Source: United Kingdom Atomic Energy Authority, 1981.

### A.2 Centre d'Etudes Nucléaires de Saclay, CENS (CEN-Saclay)

Location — Paris, France

Director — Claude Chauvez

Parent organization — Commissariat a l'Energie Atomique (CEA)

Date established — 1949

Staff — 5800 permanent staff
2000 staff from private companies under contract

Annual budget — Budgets are not allocated to specific research centers, but rather to programs and divisions within the CEA. These divisions may carry out work at several different research centers.

Research divisions — Institute for Fundamental Research
Physics
Biology Department
Metallurgy and Nuclear Fuels Research
Reactor Research and Development
Chemistry
Energy Transfer and Conversion Department
Institute for Nuclear Protection and Safety
Protection Department
National Institute of Nuclear Science and Technology
International Data Processing Services Company (CISI)

## A.3 Toegepast-Natuurwetenschappelijk Onderzoek (TNO) (Center Organization for Applied Scientific Research)

Location — Headquarters, The Hague
The three major laboratories are located in Rijswijk, Apeldoorn, and Delft, but companies of TNO are located at many different centers throughout the country.

Chairman — W. A. de Jong

Parent organization — Financially supported by different government departments through the Ministry of Finance.

Date established — Organization for Industrial Research TNO (1935)
Organization for Nutrition and Food Research TNO (1940)
National Defense Research Organization TNO (1946)
Organization for Health Research TNO (1949)

Staff — 5000

Annual budget — $200 million of which $20 million is for energy research

Research divisions — Technology for Society
Building and Metals Research
Industrial Products and Services
Nutrition and Food Research
Health Research
National Defense Research
Technical Scientific Services
Group TNO Policy Studies and Information

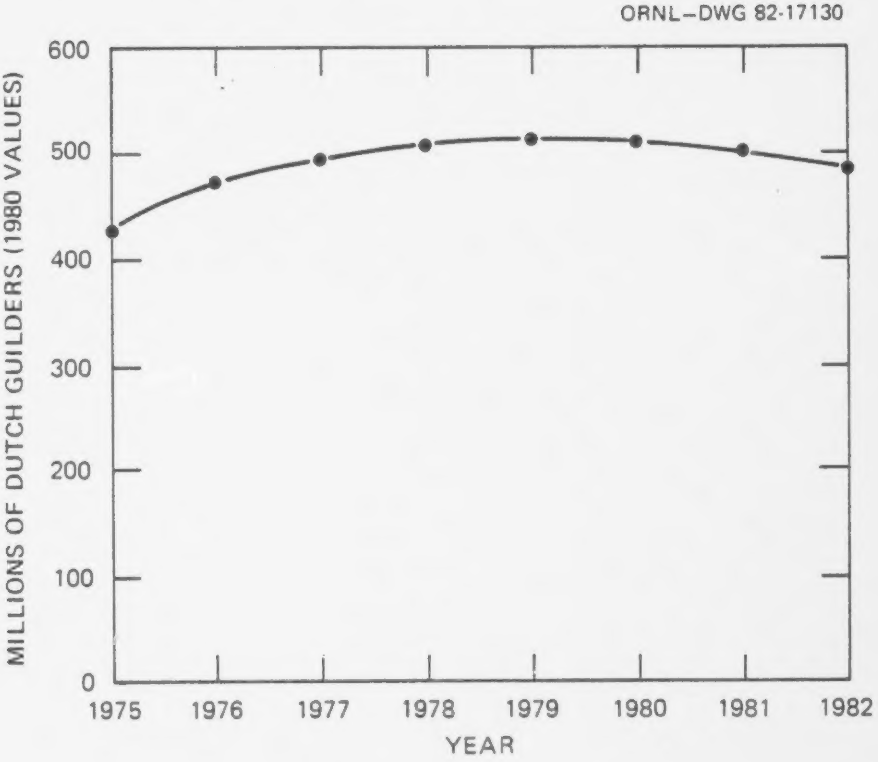


Fig. A.4. Annual budget of TNO.

### A.4 Studsvik Energiteknik AB

Location — Nyköping, Sweden; 90 km (56 miles) southwest of Stockholm

President — Kjell Hakansson

Executive Vice-President — Lars-Åke Nöjd

Date established — 1947 (as Aktiebolaget Atomenergi)

Staff — 1100

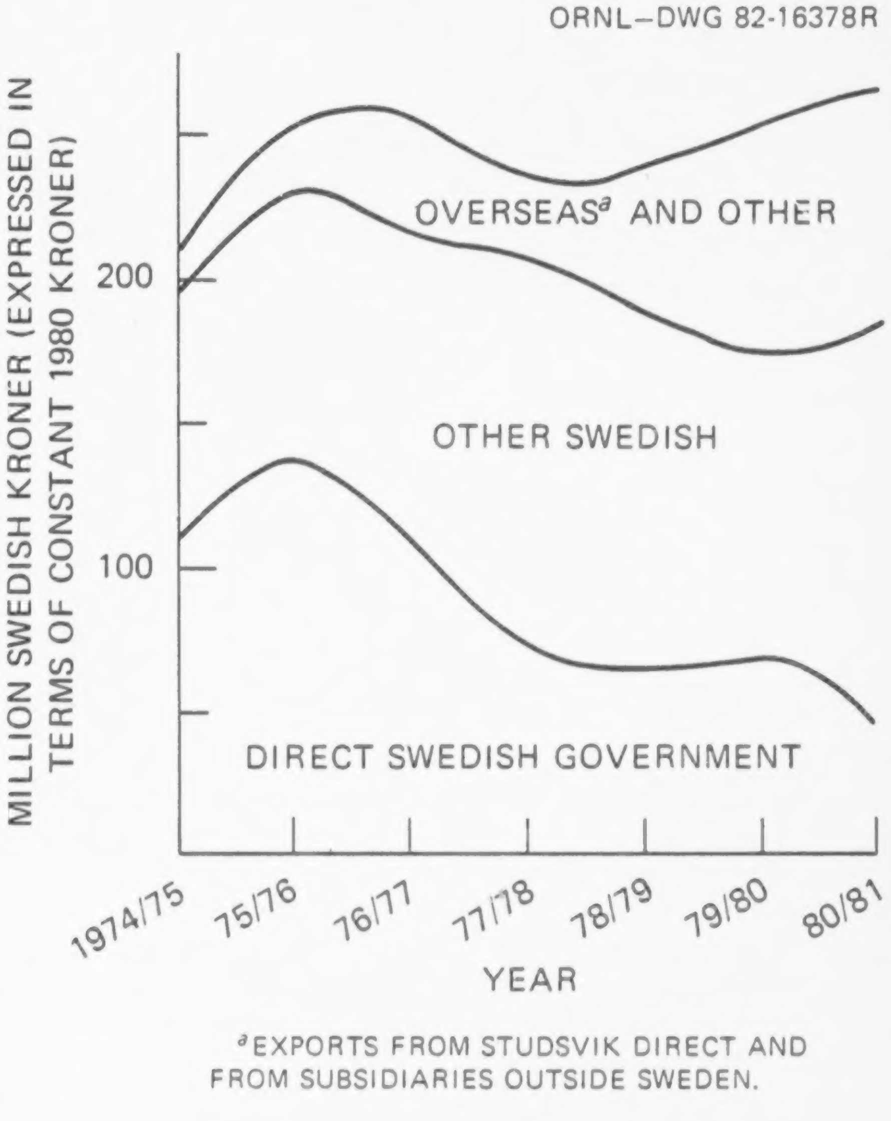
Annual sales (including subsidiaries) — $40 million

Functional management — Matrix

Divisions — Nuclear Technology (Staff of 380)
  - Fuel Technology
  - Reactor Technology
  - Waste Technology

Energy Technology (Staff of 160)
  - Chemical Technology
  - Materials Application and Technology
  - Thermal Engineering

Technical Services (Staff of 310)



$^a$EXPORTS FROM STUDSVIK DIRECT AND FROM SUBSIDIARIES OUTSIDE SWEDEN.

Fig. A.5. Business volume of Studsvik. Source: Based on data from *Directors' Report 1979/80* (Studsvik Energiteknik AB, Nyköping) and *Årsberättelse 1980/81* (Studsvik Energiteknik AB, Nyköping).

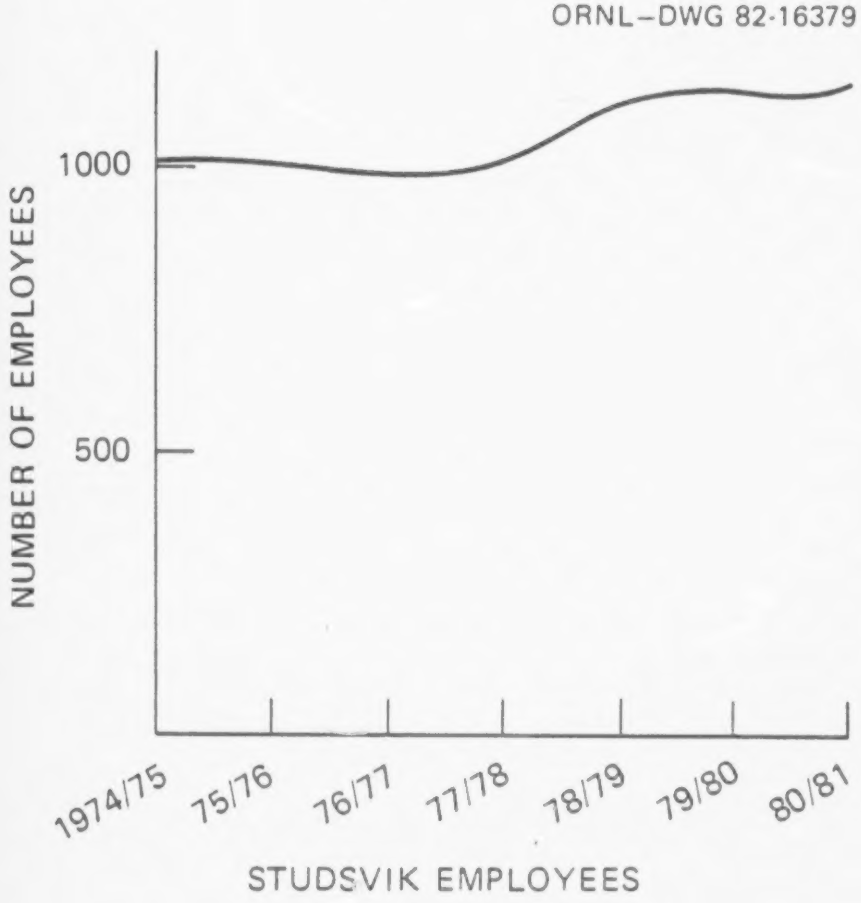


Fig. A.6. Studsvik employees. Source: Based on data from *Directors' Report 1979/80* (Studsvik Energiteknik AB, Nyköping) and *Årsberättelse 1980/81* (Studsvik Energiteknik AB, Nyköping).

## A.5 Japan Atomic Energy Research Institute-Tokai Research Establishment (JAERI-Tokai)

Location — Tokai-mura, Ibaraki-ken, Japan

Director — Hiroshi Ishikawa

Parent organization — Japan Atomic Energy Research Institute, funding from Japan's Science and Technology Agency

Date established — 1957

Staff — 1500

Annual budget — about $300 million

Research divisions — Engineering Services
- Health Physics
  - Computing Center
- Reactor Engineering
- Nuclear Fuel Research
- Physics
- Chemistry
- High-Temperature Engineering
- Research Reactor
- Japan Power Demonstration Reactor
  - Office of Fusion Research Establishment
- Reactor Safety Research Center
  - Reactor Safety
  - Reactor Safety Evaluation
  - Reactor Fuel Examination
  - Environmental Safety Research
- Fusion Research and Development Center
  - Large Tokamak Development
  - Thermonuclear Fusion Research

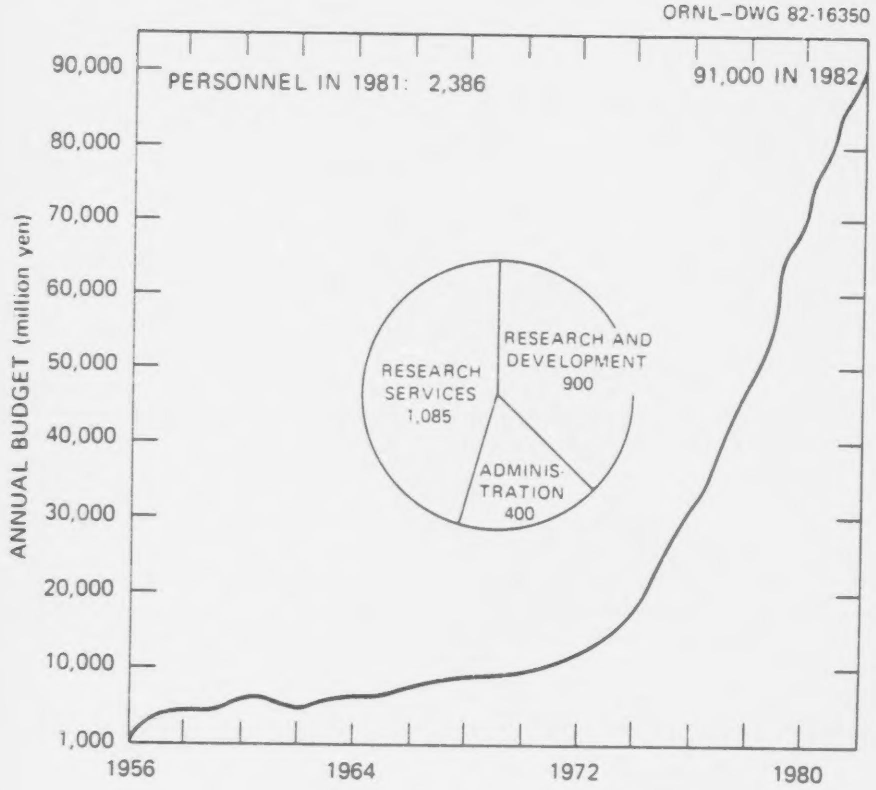


Fig. A.7. JAERI budget and personnel 1956-1982. Source: Japan Atomic Energy Research Institute, 1981.

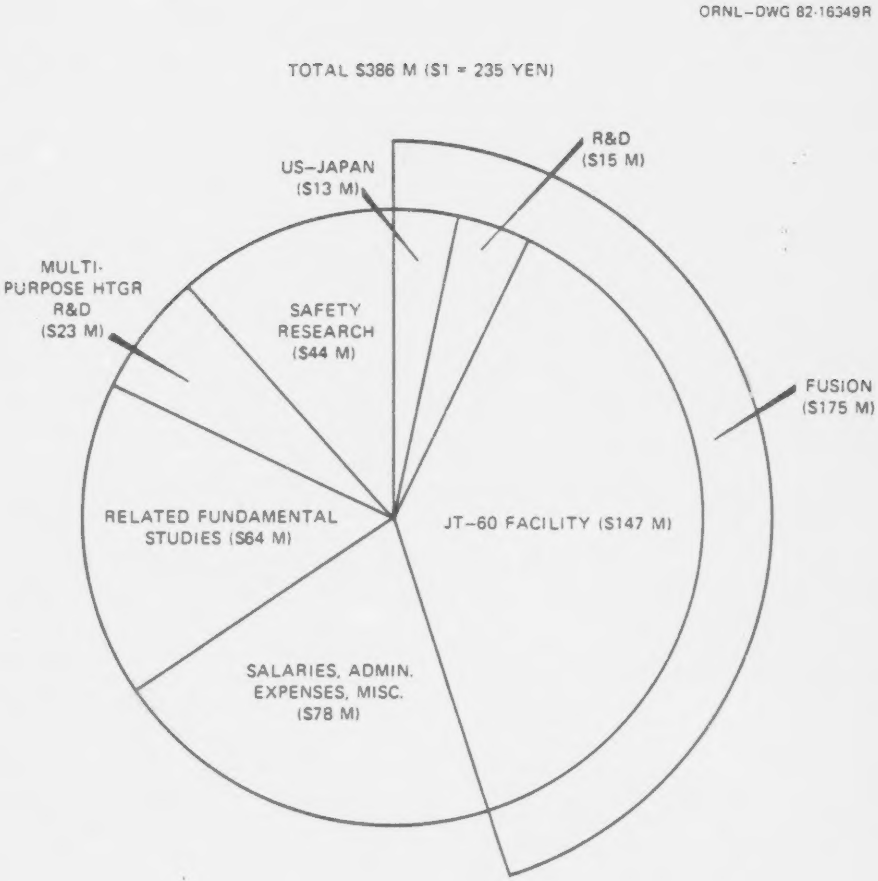


Fig. A.8. JAERI budget appropriation for FY 1982. Source: Japan Atomic Energy Research Institute, 1982.

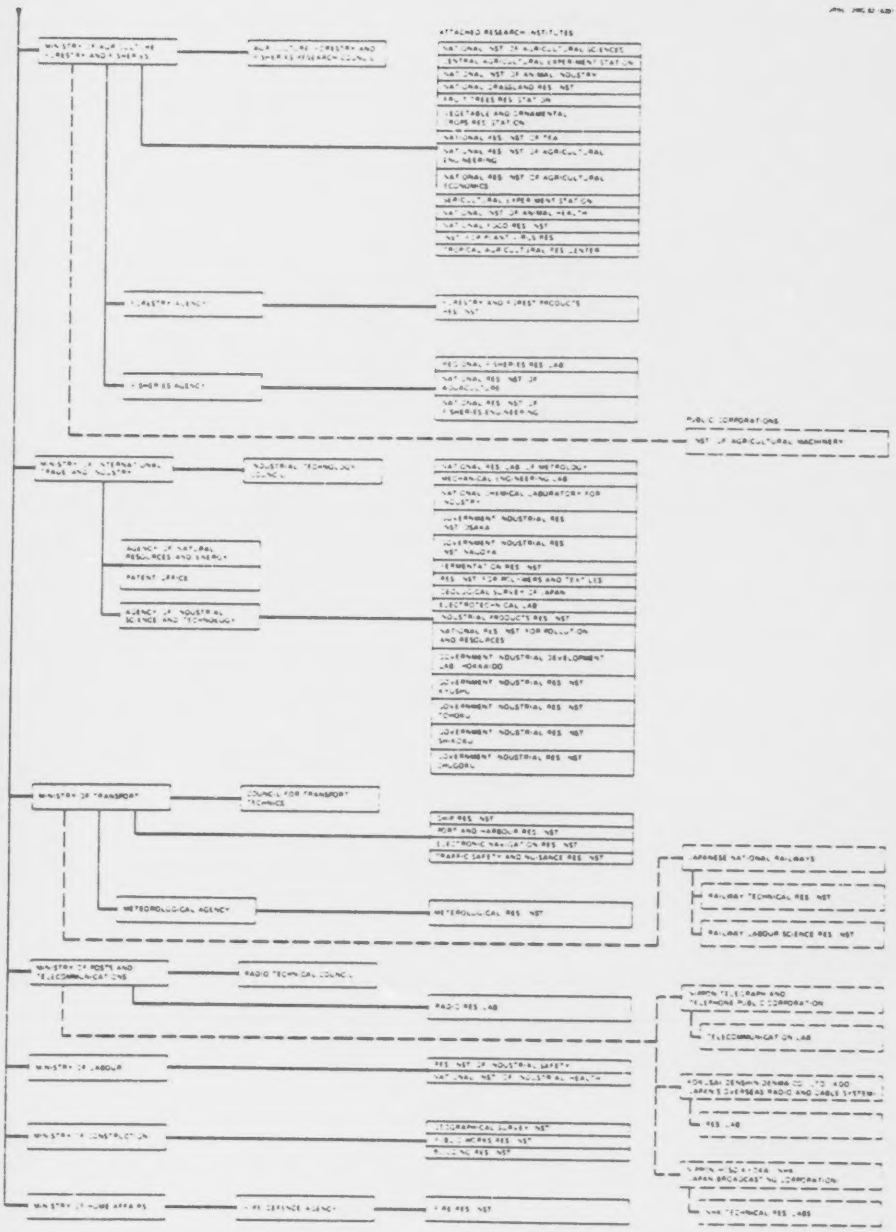

MINISTRY OF AGRICULTURE FORESTRY AND FISHERIES
AGRICULTURE FORESTRY AND FISHERIES RESEARCH COUNCIL
ATTACHED RESEARCH INSTITUTES
NATIONAL INST OF AGRICULTURAL SCIENCES
CENTRAL AGRICULTURAL EXPERIMENT STATION
NATIONAL INST OF ANIMAL INDUSTRY
NATIONAL GRASSLAND RES INST
FRUIT TREES RES STATION
VEGETABLE AND ORNAMENTAL CROPS RES STATION
NATIONAL RES INST OF TEA
NATIONAL RES INST OF AGRICULTURAL ENGINEERING
NATIONAL RES INST OF AGRICULTURAL ECONOMICS
SERICULTURAL EXPERIMENT STATION
NATIONAL INST OF ANIMAL HEALTH
NATIONAL FOOD RES INST
INST FOR PLANT VIRUS RES
TROPICAL AGRICULTURAL RES CENTER
FORESTRY AGENCY
FORESTRY AND FOREST PRODUCTS RES INST
FISHERIES AGENCY
REGIONAL FISHERIES RES LAB
NATIONAL RES INST OF AQUACULTURE
NATIONAL RES INST OF FISHERIES ENGINEERING
PUBLIC CORPORATIONS
INST OF AGRICULTURAL MACHINERY
MINISTRY OF INTERNATIONAL TRADE AND INDUSTRY
INDUSTRIAL TECHNOLOGY COUNCIL
AGENCY OF NATURAL RESOURCES AND ENERGY
PATENT OFFICE
AGENCY OF INDUSTRIAL SCIENCE AND TECHNOLOGY
NATIONAL RES LAB OF METROLOGY
MECHANICAL ENGINEERING LAB
NATIONAL CHEMICAL LABORATORY FOR INDUSTRY
GOVERNMENT INDUSTRIAL RES INST OSAKA
GOVERNMENT INDUSTRIAL RES INST NAGOYA
FERMENTATION RES INST
RES INST FOR POLYMERS AND TEXTILES
GEOLOGICAL SURVEY OF JAPAN
ELECTROTECHNICAL LAB
INDUSTRIAL PRODUCTS RES INST
NATIONAL RES INST FOR POLLUTION AND RESOURCES
GOVERNMENT INDUSTRIAL DEVELOPMENT LAB HOKKAIDO
GOVERNMENT INDUSTRIAL RES INST KYUSHU
GOVERNMENT INDUSTRIAL RES INST TOHOKU
GOVERNMENT INDUSTRIAL RES INST SHIKOKU
GOVERNMENT INDUSTRIAL RES INST CHUGOKU
MINISTRY OF TRANSPORT
COUNCIL FOR TRANSPORT TECHNICS
SHIP RES INST
PORT AND HARBOUR RES INST
ELECTRONIC NAVIGATION RES INST
TRAFFIC SAFETY AND NUISANCE RES INST
METEOROLOGICAL AGENCY
METEOROLOGICAL RES INST
JAPANESE NATIONAL RAILWAYS
RAILWAY TECHNICAL RES INST
RAILWAY LABOUR SCIENCE RES INST
MINISTRY OF POSTS AND TELECOMMUNICATIONS
RADIO TECHNICAL COUNCIL
RADIO RES LAB
NIPPON TELEGRAPH AND TELEPHONE PUBLIC CORPORATION
TELECOMMUNICATION LAB
MINISTRY OF LABOUR
RES INST OF INDUSTRIAL SAFETY
NATIONAL INST OF INDUSTRIAL HEALTH
KOKUSAI DENSHIN DENWA CO LTD (KDD) JAPAN'S OVERSEAS RADIO AND CABLE SYSTEM
RES LAB
MINISTRY OF CONSTRUCTION
GEOGRAPHICAL SURVEY INST
PUBLIC WORKS RES INST
BUILDING RES INST
NIPPON HOSO KYOKAI (NHK) JAPAN BROADCASTING CORPORATION
NHK TECHNICAL RES LABS
MINISTRY OF HOME AFFAIRS
FIRE DEFENCE AGENCY
FIRE RES INST

Fig. A.9. Administrative structure of science and technology in Japan. Source: "STA Its Role and Activities 1981." Science and Technology Agency, Tokyo.

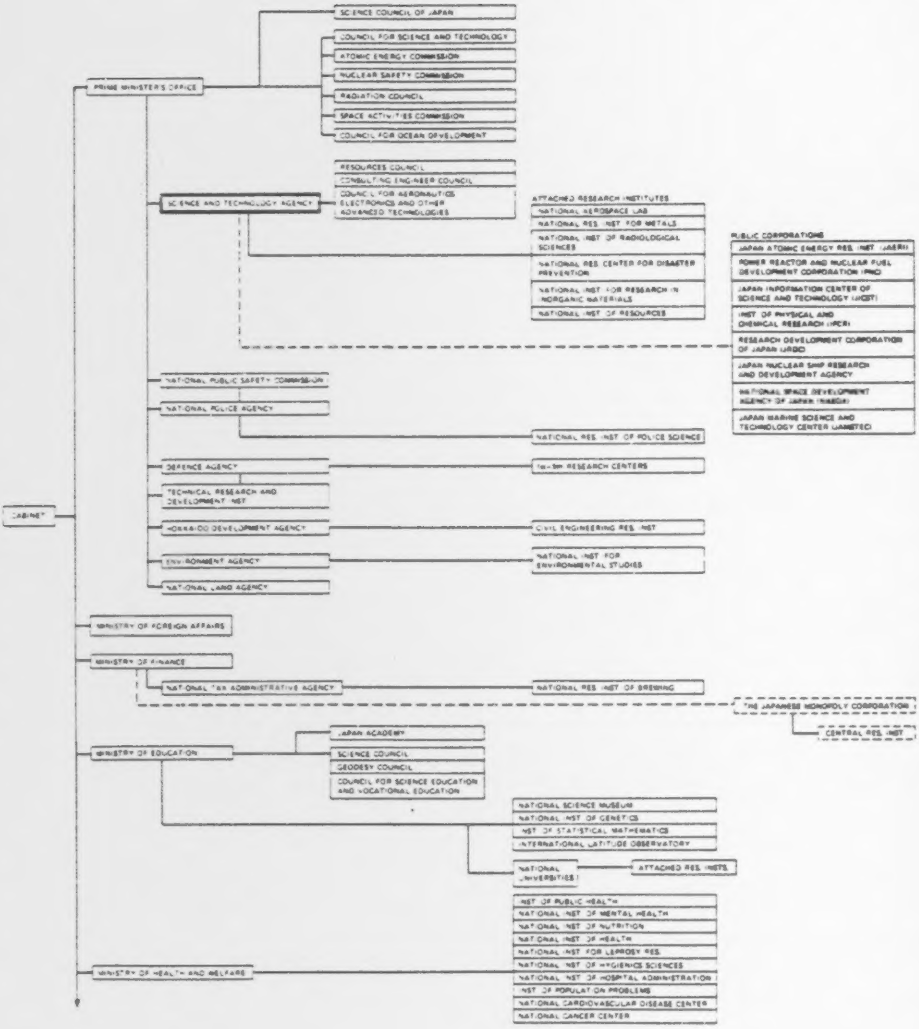
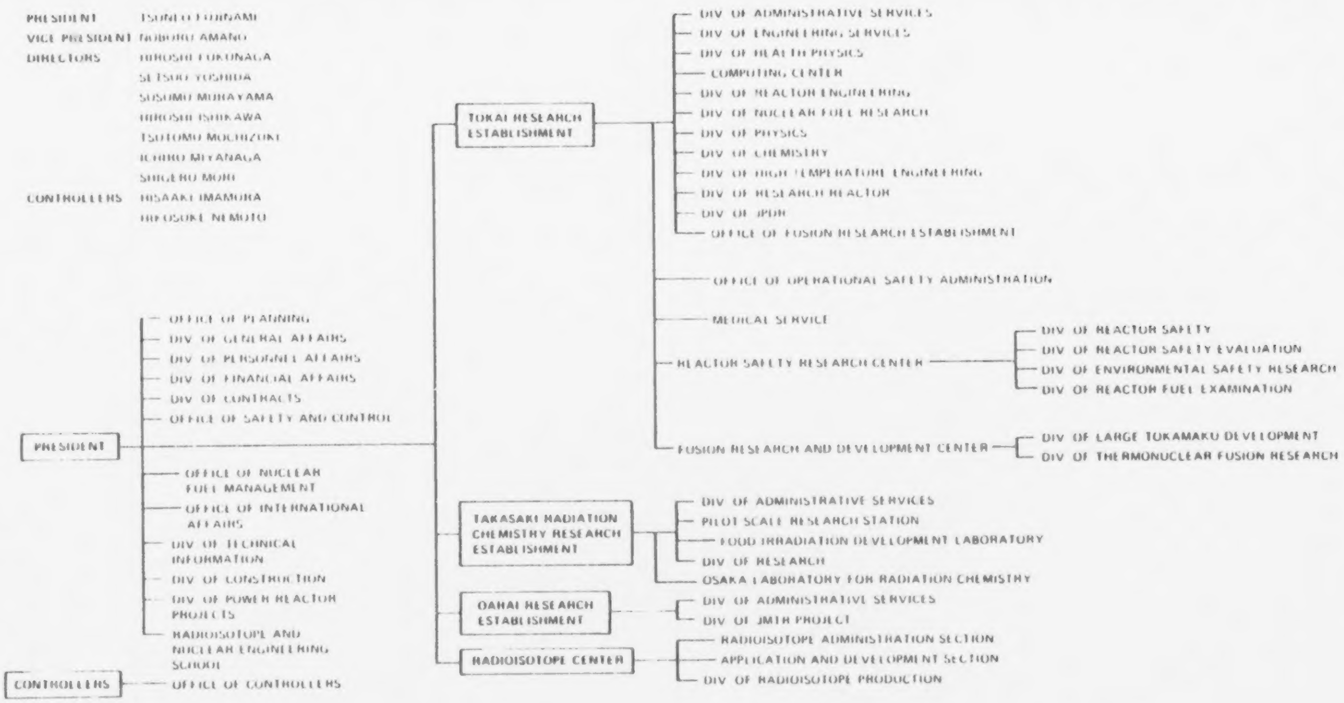

CABINET
PRIME MINISTER'S OFFICE
SCIENCE COUNCIL OF JAPAN
COUNCIL FOR SCIENCE AND TECHNOLOGY
ATOMIC ENERGY COMMISSION
NUCLEAR SAFETY COMMISSION
RADIATION COUNCIL
SPACE ACTIVITIES COMMISSION
COUNCIL FOR OCEAN DEVELOPMENT
SCIENCE AND TECHNOLOGY AGENCY
RESOURCES COUNCIL
CONSULTING ENGINEER COUNCIL
COUNCIL FOR AERONAUTICS ELECTRONICS AND OTHER ADVANCED TECHNOLOGIES
ATTACHED RESEARCH INSTITUTES
NATIONAL AEROSPACE LAB
NATIONAL RES. INST. FOR METALS
NATIONAL INST. OF RADIOLOGICAL SCIENCES
NATIONAL RES. CENTER FOR DISASTER PREVENTION
NATIONAL INST. FOR RESEARCH IN INORGANIC MATERIALS
NATIONAL INST. OF RESOURCES
PUBLIC CORPORATIONS
JAPAN ATOMIC ENERGY RES. INST. (JAERI)
POWER REACTOR AND NUCLEAR FUEL DEVELOPMENT CORPORATION (PNC)
JAPAN INFORMATION CENTER OF SCIENCE AND TECHNOLOGY (JICST)
INST. OF PHYSICAL AND CHEMICAL RESEARCH (IPCR)
RESEARCH DEVELOPMENT CORPORATION OF JAPAN (JRDC)
JAPAN NUCLEAR SHIP RESEARCH AND DEVELOPMENT AGENCY
NATIONAL SPACE DEVELOPMENT AGENCY OF JAPAN (NASDA)
JAPAN MARINE SCIENCE AND TECHNOLOGY CENTER (JAMSTEC)
NATIONAL PUBLIC SAFETY COMMISSION
NATIONAL POLICE AGENCY
NATIONAL RES. INST. OF POLICE SCIENCE
DEFENCE AGENCY
1st–5th RESEARCH CENTERS
TECHNICAL RESEARCH AND DEVELOPMENT INST.
HOKKAIDO DEVELOPMENT AGENCY
CIVIL ENGINEERING RES. INST.
ENVIRONMENT AGENCY
NATIONAL INST. FOR ENVIRONMENTAL STUDIES
NATIONAL LAND AGENCY
MINISTRY OF FOREIGN AFFAIRS
MINISTRY OF FINANCE
NATIONAL TAX ADMINISTRATIVE AGENCY
NATIONAL RES. INST. OF BREWING
THE JAPANESE MONOPOLY CORPORATION
CENTRAL RES. INST.
MINISTRY OF EDUCATION
JAPAN ACADEMY
SCIENCE COUNCIL
GEODESY COUNCIL
COUNCIL FOR SCIENCE EDUCATION AND VOCATIONAL EDUCATION
NATIONAL SCIENCE MUSEUM
NATIONAL INST. OF GENETICS
INST. OF STATISTICAL MATHEMATICS
INTERNATIONAL LATITUDE OBSERVATORY
NATIONAL UNIVERSITIES
ATTACHED RES. INSTS.
MINISTRY OF HEALTH AND WELFARE
INST. OF PUBLIC HEALTH
NATIONAL INST. OF MENTAL HEALTH
NATIONAL INST. OF NUTRITION
NATIONAL INST. OF HEALTH
NATIONAL INST. FOR LEPROSY RES.
NATIONAL INST. OF HYGIENICS SCIENCES
NATIONAL INST. OF HOSPITAL ADMINISTRATION
INST. OF POPULATION PROBLEMS
NATIONAL CARDIOVASCULAR DISEASE CENTER
NATIONAL CANCER CENTER

Fig. A.9. Continued.


PRESIDENT TSUNEO FUJINAMI
VICE PRESIDENT NOBORU AMANO
DIRECTORS HIROSHI FUKUNAGA
SETSUO YOSHIDA
SUSUMU MURAYAMA
HIROSHI ISHIKAWA
TSUTOMU MOCHIZUKI
ICHIRO MIYANAGA
SHIGERU MORI
CONTROLLERS HISAAKI IMAMURA
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PRESIDENT
OFFICE OF PLANNING
DIV OF GENERAL AFFAIRS
DIV OF PERSONNEL AFFAIRS
DIV OF FINANCIAL AFFAIRS
DIV OF CONTRACTS
OFFICE OF SAFETY AND CONTROL
OFFICE OF NUCLEAR FUEL MANAGEMENT
OFFICE OF INTERNATIONAL AFFAIRS
DIV OF TECHNICAL INFORMATION
DIV OF CONSTRUCTION
DIV OF POWER REACTOR PROJECTS
RADIOISOTOPE AND NUCLEAR ENGINEERING SCHOOL
CONTROLLERS
OFFICE OF CONTROLLERS
TOKAI RESEARCH ESTABLISHMENT
DIV OF ADMINISTRATIVE SERVICES
DIV OF ENGINEERING SERVICES
DIV OF HEALTH PHYSICS
COMPUTING CENTER
DIV OF REACTOR ENGINEERING
DIV OF NUCLEAR FUEL RESEARCH
DIV OF PHYSICS
DIV OF CHEMISTRY
DIV OF HIGH TEMPERATURE ENGINEERING
DIV OF RESEARCH REACTOR
DIV OF JPDR
OFFICE OF FUSION RESEARCH ESTABLISHMENT
OFFICE OF OPERATIONAL SAFETY ADMINISTRATION
MEDICAL SERVICE
REACTOR SAFETY RESEARCH CENTER
DIV OF REACTOR SAFETY
DIV OF REACTOR SAFETY EVALUATION
DIV OF ENVIRONMENTAL SAFETY RESEARCH
DIV OF REACTOR FUEL EXAMINATION
FUSION RESEARCH AND DEVELOPMENT CENTER
DIV OF LARGE TOKAMAKU DEVELOPMENT
DIV OF THERMONUCLEAR FUSION RESEARCH
TAKASAKI RADIATION CHEMISTRY RESEARCH ESTABLISHMENT
DIV OF ADMINISTRATIVE SERVICES
PILOT SCALE RESEARCH STATION
FOOD IRRADIATION DEVELOPMENT LABORATORY
DIV OF RESEARCH
OSAKA LABORATORY FOR RADIATION CHEMISTRY
OARAI RESEARCH ESTABLISHMENT
DIV OF ADMINISTRATIVE SERVICES
DIV OF JMTR PROJECT
RADIOISOTOPE CENTER
RADIOISOTOPE ADMINISTRATION SECTION
APPLICATION AND DEVELOPMENT SECTION
DIV OF RADIOISOTOPE PRODUCTION

Fig. A.10. Organization of JAERI. Source: Japan Atomic Energy Research Institute, 1981.

# APPENDIX B

## THE REQUIREMENTS BOARDS OF THE UNITED KINGDOM DEPARTMENT OF INDUSTRY

E. L. Preston and C. D. West

Prior to 1971, there was no clear-cut research and development (R&D) policy in British governmental departments and establishments. In 1971 Lord Rothschild, the first head of the Central Policy Review Staff, a cabinet office, was commissioned to study the organization and management of R&D within the government and to make recommendations for an improved policy.

In his report *A Framework for Government Research and Development* (CMND 4814. HMSO 1971) Lord Rothschild stated the premise that applied R&D (i.e., R&D with a practical application as its objective) must be done on a customer-contractor basis: "The customer says what he wants; the contractor does it (if he can); and the customer pays."

At the time, the Department of Education and Science (DES) was primarily responsible, through its University Grants Committee, for supporting basic research at the universities and colleges. Through its Research Councils,* DES dealt with research at its own establishments, and commissioned research. Rothschild proposed that part of the Research Council's budgets be transferred to Customer Departments to aid with their commissioned research.

Rothschild further recommended that the Department of Industry (DOI), responsible for industrial research, be guided in its placing of commissions to its Industrial Research Establishments, industry and the universities, by a set of Requirements Boards. These Boards would cover a number of industrial fields and would reflect customer interests in the Department, industry, and elsewhere. There are now five industrial Requirements Boards, namely for Mechanical and Electrical Engineering; Electronics and Avionics; Materials and Chemicals; Textiles and Other Manufacturers; and Metrology and Standards. The DOI Chief Scientist would also have funds available for commissioning research in areas other than those listed or where R&D funding was low.

The organization shown in Fig. B.1 is representative of the recommended structure. Not all departments in the government have this particular arrangement, but all bear some resemblance to it. Each department considered as a customer, was to define its work needs with the aid of its Chief Scientist. The independent members of the Requirements Boards, drawn from industry, government and academia, provide technical advice to the DOI Chief Scientist on specific proposals and give preference to projects where a strong industrial involvement can be demonstrated.

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*At present these are Science Research Council (RC), Medical RC, Agricultural RC, Natural Environment RC and Social Science RC.

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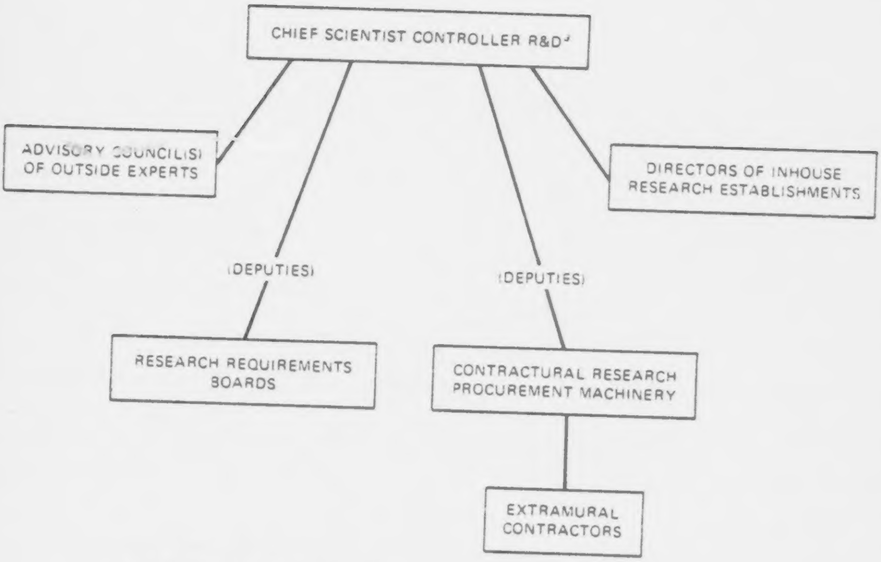
CHIEF SCIENTIST CONTROLLER R&D[a]
ADVISORY COUNCIL(S) OF OUTSIDE EXPERTS
DIRECTORS OF INHOUSE RESEARCH ESTABLISHMENTS
(DEPUTIES)
(DEPUTIES)
RESEARCH REQUIREMENTS BOARDS
CONTRACTURAL RESEARCH PROCUREMENT MACHINERY
EXTRAMURAL CONTRACTORS

[a] THE DISTINCTION BETWEEN THE CHIEF SCIENTIST AND THE CONTROLLER R&D FUNCTION IS BROADLY THAT THE FORMER ADVISES ON THE SCIENTIFIC ASPECTS OF THE DEPARTMENT'S WORK AND ON LONGER TERM RESEARCH STRATEGY WHILE THE LATTER IS PRINCIPALLY CONCERNED WITH THE EXECUTION OF THE RESEARCH PROGRAMME.

Fig. B.1. Structure of DOI. Source: CMND 7499. Review of the Framework for Government Research and Development (CMND 5046). 1979. Her Majesty's Stationery Office, London.

In 1979-1980 DOI's R&D budget was about £177 million, of which about £53 million (or about one-third of the research funds) went to nine Requirements Boards for allocation; subsequently, the Requirements Boards were consolidated (Table B.1). In the role of customer the Requirements Boards provided about £6 million to the UKAEA (which is under the control of the Secretary of State). In 1980 Harwell received about 10% of its R&D budget through the Boards; in 1981 about 13%.

**Table B.1. R&D expenditures for 1979-1980 of the United Kingdom's Department of Industry (DOI) Requirements Boards (in thousands of pounds sterling)**

| Former Title | New Title | 1979-80 | 1981 |
|---|---|---|---|
| Mechanical Engineering and Machine Tools | Mechanical and Electrical Engineering | 11,524 | |
| Ship and Marine Technology | | 4,229 | |
| Electrical Technology | | 2,097 | |
| Metrology and Standards | Metrology | 11,021 | |
| Engineering Materials | Materials and Chemicals | 8,679 | |
| Chemical and Minerals | | 6,733 | |
| Computers, Systems and Electronics | Electronics and Avionics | 6,209 | |
| Garment and Allied Industries | Textiles and Other Manufacturers | 2,087 | |
| Chief Scientist's Requirements Board | Same | 1,032 | |
| Total | | 53,661[a] | 83,000[b] |

[a] This amounts to about 30% of DOI's total research and development expenses.

[b] Not official: figures for 1982 Requirements Boards are not yet available from DOI, according to the American Embassy in London.

The Requirements Boards are said to concentrate on work with a high research content and to strive for the development of new or improved products. Attention is also given to long-term concerns. However, in the opinion of Justin Bloom, Scientific Attaché at the U.S. Embassy in London, the trend in Requirements Boards research has been toward "catching up" with current technology already developed in other countries rather than aiding technological innovation (J. Bloom personal communication with C. D. West, Oak Ridge National Laboratory, Oak Ridge, Tenn., March 9, 1982). An example of this may be seen in the underwriting of an R&D program in fiber-optic cabling, a technology for telecommunications which has already been successfully used in the United States for several years.

Figure B.2 gives an overview of the various Departments of the British government which fund or support research. Each Department may be a customer of any other Department, since any given Department has expertise which is lacking in the other Department.

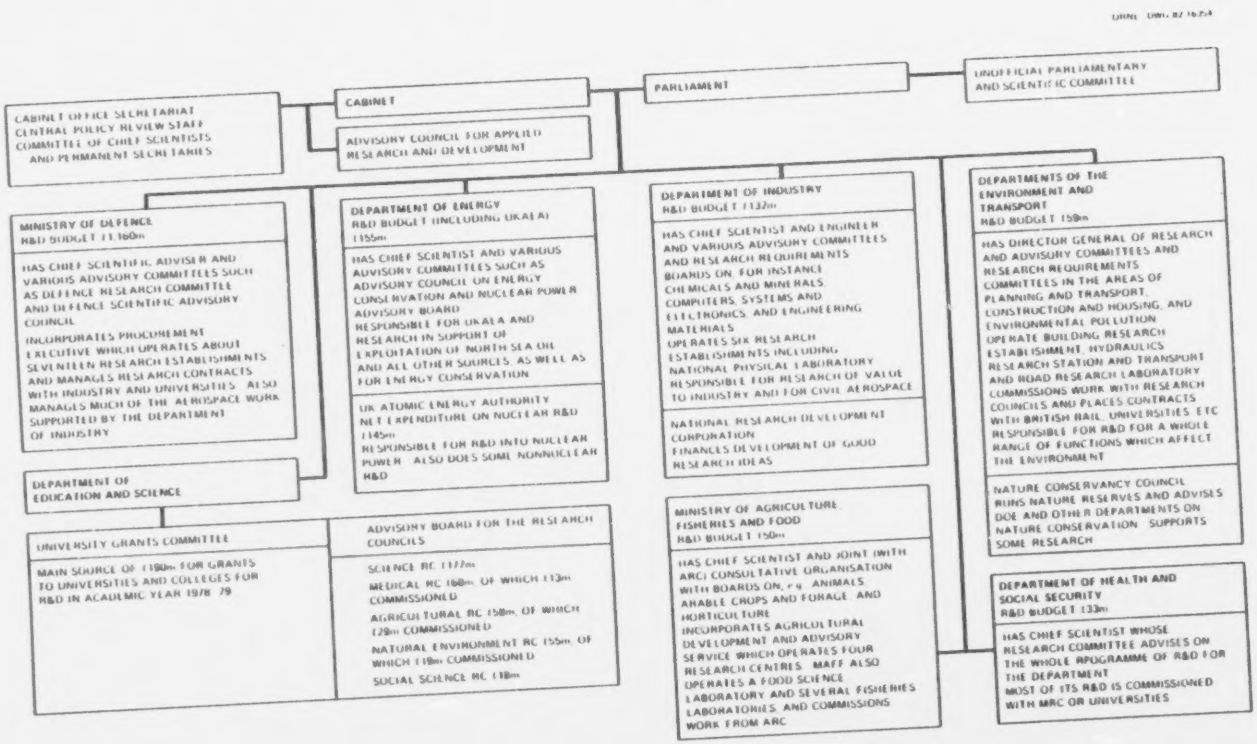
ORNL DWG. 82 16754
CABINET OFFICE SECRETARIAT
CENTRAL POLICY REVIEW STAFF
COMMITTEE OF CHIEF SCIENTISTS AND PERMANENT SECRETARIES
CABINET
ADVISORY COUNCIL FOR APPLIED RESEARCH AND DEVELOPMENT
PARLIAMENT
UNOFFICIAL PARLIAMENTARY AND SCIENTIFIC COMMITTEE
MINISTRY OF DEFENCE
R&D BUDGET £1,160m
HAS CHIEF SCIENTIFIC ADVISER AND VARIOUS ADVISORY COMMITTEES SUCH AS DEFENCE RESEARCH COMMITTEE AND DEFENCE SCIENTIFIC ADVISORY COUNCIL
INCORPORATES PROCUREMENT EXECUTIVE WHICH OPERATES ABOUT SEVENTEEN RESEARCH ESTABLISHMENTS AND MANAGES RESEARCH CONTRACTS WITH INDUSTRY AND UNIVERSITIES. ALSO MANAGES MUCH OF THE AEROSPACE WORK SUPPORTED BY THE DEPARTMENT OF INDUSTRY
DEPARTMENT OF EDUCATION AND SCIENCE
UNIVERSITY GRANTS COMMITTEE
MAIN SOURCE OF £190m FOR GRANTS TO UNIVERSITIES AND COLLEGES FOR R&D IN ACADEMIC YEAR 1978 79
DEPARTMENT OF ENERGY
R&D BUDGET (INCLUDING UKAEA) £155m
HAS CHIEF SCIENTIST AND VARIOUS ADVISORY COMMITTEES SUCH AS ADVISORY COUNCIL ON ENERGY CONSERVATION AND NUCLEAR POWER ADVISORY BOARD
RESPONSIBLE FOR UKAEA AND RESEARCH IN SUPPORT OF EXPLOITATION OF NORTH SEA OIL AND ALL OTHER SOURCES, AS WELL AS FOR ENERGY CONSERVATION
UK ATOMIC ENERGY AUTHORITY
NET EXPENDITURE ON NUCLEAR R&D £145m
RESPONSIBLE FOR R&D INTO NUCLEAR POWER. ALSO DOES SOME NONNUCLEAR R&D
ADVISORY BOARD FOR THE RESEARCH COUNCILS
SCIENCE RC £177m
MEDICAL RC £60m, OF WHICH £13m COMMISSIONED
AGRICULTURAL RC £58m, OF WHICH £29m COMMISSIONED
NATURAL ENVIRONMENT RC £55m, OF WHICH £19m COMMISSIONED
SOCIAL SCIENCE RC £18m
DEPARTMENT OF INDUSTRY
R&D BUDGET £132m
HAS CHIEF SCIENTIST AND ENGINEER AND VARIOUS ADVISORY COMMITTEES AND RESEARCH REQUIREMENTS BOARDS ON, FOR INSTANCE, CHEMICALS AND MINERALS, COMPUTERS, SYSTEMS AND ELECTRONICS, AND ENGINEERING MATERIALS
OPERATES SIX RESEARCH ESTABLISHMENTS INCLUDING NATIONAL PHYSICAL LABORATORY
RESPONSIBLE FOR RESEARCH OF VALUE TO INDUSTRY AND FOR CIVIL AEROSPACE
NATIONAL RESEARCH DEVELOPMENT CORPORATION
FINANCES DEVELOPMENT OF GOOD RESEARCH IDEAS
MINISTRY OF AGRICULTURE, FISHERIES AND FOOD
R&D BUDGET £50m
HAS CHIEF SCIENTIST AND JOINT (WITH ARC) CONSULTATIVE ORGANISATION WITH BOARDS ON, e.g., ANIMALS, ARABLE CROPS AND FORAGE, AND HORTICULTURE
INCORPORATES AGRICULTURAL DEVELOPMENT AND ADVISORY SERVICE WHICH OPERATES FOUR RESEARCH CENTRES. MAFF ALSO OPERATES A FOOD SCIENCE LABORATORY AND SEVERAL FISHERIES LABORATORIES, AND COMMISSIONS WORK FROM ARC
DEPARTMENTS OF THE ENVIRONMENT AND TRANSPORT
R&D BUDGET £59m
HAS DIRECTOR GENERAL OF RESEARCH AND ADVISORY COMMITTEES AND RESEARCH REQUIREMENTS COMMITTEES IN THE AREAS OF PLANNING AND TRANSPORT, CONSTRUCTION AND HOUSING, AND ENVIRONMENTAL POLLUTION
OPERATE BUILDING RESEARCH ESTABLISHMENT, HYDRAULICS RESEARCH STATION AND TRANSPORT AND ROAD RESEARCH LABORATORY
COMMISSIONS WORK WITH RESEARCH COUNCILS AND PLACES CONTRACTS WITH BRITISH RAIL, UNIVERSITIES ETC
RESPONSIBLE FOR R&D FOR A WHOLE RANGE OF FUNCTIONS WHICH AFFECT THE ENVIRONMENT
NATURE CONSERVANCY COUNCIL
RUNS NATURE RESERVES AND ADVISES DOE AND OTHER DEPARTMENTS ON NATURE CONSERVATION. SUPPORTS SOME RESEARCH
DEPARTMENT OF HEALTH AND SOCIAL SECURITY
R&D BUDGET £33m
HAS CHIEF SCIENTIST WHOSE RESEARCH COMMITTEE ADVISES ON THE WHOLE RPOGRAMME OF R&D FOR THE DEPARTMENT
MOST OF ITS R&D IS COMMISSIONED WITH MRC OR UNIVERSITIES

Fig. 8.2. The main government organization for science and technology in Britain, 1979. Source: The structure of the figure and some of the notes are from the *Nature* guide "How Britain runs its science" (London: Macmillan Journals, 1978). Budgetary details are from *Supply Estimates, 1979-80, Memorandum by the Chief Secretary to the Treasury* (London: HMSO, CMND 7524, 1979 ), table 7, and *Supply Estimates, 1979-80, Class X, Education and Libraries Science and Arts* (London: HMS HC 266, 1979). Further details of departmental arrangements can be found in *Review of the Framework for Government Research and Development (CMND 5046)* (London: HMSO, CMND 7499, 1979).

# APPENDIX C

# IMPACT OF THE PRESIDENT'S FY 1983 BUDGET

I. Spiewak and J. P. Nichols

## C.1 Introduction

The Multiprogram Laboratory (MPL) Panel of the ERAB requested that an analysis be conducted of the impacts of the FY 1983 budget on the DOE MPLs. The Office of Energy Research solicited budget data on FY 1981, FY 1982, and FY 1983 from DOE R&D program offices. The data requested were supplied with the following exceptions.

1. Defense Programs supplied data only for defense nuclear waste.
2. Nuclear Energy supplied complete budget data but indicated that the FY 1983 budget for Advanced Isotope Separation would not be allocated until one of three competing processes was selected.
3. Fossil Energy supplied complete budget data but indicated that they had not yet allocated the FY 1983 budget.

Subsequently, W. S. Heffelfinger, Assistant Secretary, Management Administration, presented the Controller's FY 1983 estimates for the MPLs at the April 8, 1982, meeting of ERAB. His estimates are presented here as well and compared with those of our study.

## C.2 Analysis

It was necessary to obtain supplementary data from the laboratories' Institutional Plans to estimate the impacts of the FY 1982 and FY 1983 budgets. The most important data obtained from the plans concerned the Program and Work-for-Others budgets and the procurement expenditures. It should be recognized that the data and projections obtained from the Institutional Plans are less accurate than those obtained from DOE and are frequently on the optimistic side. Nevertheless, we believe that the tables shown here present a reasonable estimate of the effects.

In interpreting the tables that follow, the reader should remember that budget increases of about 10% per year would be required to compensate for inflation.

Table C.1 shows the budget estimates for [illegible]s Laboratory with all budgets appearing to be stable except for Fossil Energy. The overall trend is down about 6% from FY 1981 to FY 1983.

Table C.1. MPL budget[a]
($ in millions)

| Ames | FY 1981 | | FY 1982 | | FY 1983 | |
|---|---|---|---|---|---|---|
| | Total[b] | Procurement[c] | Total[b] | Procurement[c] | Total[b] | Procurement[c] |
| Defense activities[c] | 0.1 | 0 | 0.2 | 0 | 0.2 | 0 |
| General science | 1.1 | 0.1 | 1.1 | 0.2 | 1.1 | 0.2 |
| Solar, geothermal, electrical energy, and storage | 0.3 | 0.1 | 0 | 0 | 0 | 0 |
| Magnetic fusion | 0 | 0 | 0 | 0 | 0 | 0 |
| Nuclear | 0.2 | | 0.6 | 0 | 0 | 0 |
| Environment | 1.0 | 0.1 | 0.9 | 0.1 | 0.7 | 0.1 |
| Supporting research | 10.8 | 1.3 | 11.3 | 1.5 | 12.3 | 1.6 |
| Fossil | 2.6 | 0.5 | 0.8 | 0.3 | 0.1[d] | 0 |
| Conservation | 0 | 0 | 0 | 0[b] | 0 | 0 |
| Other DOE[c] | 0 | 0 | 0 | 0 | 0 | 0 |
| DOE total | 16.1 | 2.1 | 14.9 | 2.1 | 14.4 | 1.9 |
| Work-for-others[c] | 2.0 | 0.4 | 3.3 | 0.5 | 2.6 | 0.4 |
| Total | 18.1 | 2.5 | 18.2 | 2.6 | 17.0 | 2.3 |

[a] Budget authority.

[b] Sum of operating in addition to capital equipment and construction funds (based upon DOE data unless otherwise indicated).

[c] Data taken from Institutional Plan, unless otherwise indicated.

[d] Fossil program prorated to retain 1982 market share.

Table C.2 shows the budget estimates for Argonne National Laboratory (ANL). ANL budgets for Fossil Energy, Storage, and Conservation trend downward so that the loss in overall budget is about 11% from FY 1981 to FY 1983. The table shows that there was a significant subcontract activity in those programs being reduced; therefore, the negative impact on the internal budget would be somewhat less than on the overall budget.

Table C.3 shows the budget estimates for Brookhaven National Laboratory (BNL). The BNL budget picture is distorted by the funding of ISABELLE; in FY 1981 BNL received a considerable amount of budget authority for construction of ISABELLE which carried over to finance procurement in later years. There have been only small amounts of vulnerable funding at BNL; therefore, the employment level has been reduced only slightly from its 1980 peak. However, the present budget analysis does not address the question of whether BNL will have enough resources to support ISABELLE's future costs.

Table C.4 shows that Lawrence Berkeley Laboratory's (LBL) budget is affected about 19% between FY 1981 and FY 1983, the result of reductions in major Solar and Conservation programs and smaller reductions in Environmental programs.

Table C.5 shows that Lawrence Livermore National Laboratory (LLNL) has a reasonably healthy budgetary situation overall and may benefit further from funding of their Advanced Isotope Separation process. The increases in Defense and Fusion programs tend to compensate for losses in Solar and Fossil, but FY 1983 is nonetheless expected to be below FY 1982. It should be noted that the FY 1983 DOE Controller's projection for LLNL (Table C.12) is less optimistic than ours.

Table C.6 shows that Los Alamos National Laboratory (LANL) is in a situation similar to LLNL. However, the details show major losses in Nuclear, Solar/Geothermal and Fossil programs.

Table C.7 shows that Oak Ridge National Laboratory (ORNL) suffers a gross budget loss of 19% between FY 1981 and FY 1983. The cuts occur in Electrical Energy, Storage, Nuclear, Environmental, Fossil, and Conservation programs. Because these programs have many subcontracts, the personnel level at ORNL might be expected to be affected less severely than the budget.

Table C.8 shows that Pacific Northwest Laboratory (PNL) faces major cuts in its programs. PNL has less of a scientific base technology program than the above MPLs.

Table C.9 shows Sandia will have to accept major cuts in its large Solar and Fossil programs. However, the growth in defense is expected to be comparable to the losses.

Table C.10 summarizes and compares the impacts on the MPLs. Overall, the increases in Defense programs balance losses in the Energy programs. The three weapons laboratories clearly do best. Table C.10

### Table C.2. MPL budget[a]
### ($ in millions)

| ANL | FY 1981 | | FY 1982 | | FY 1983 | |
|---|---|---|---|---|---|---|
| | Total[b] | Procurement[c] | Total[b] | Procurement[c] | Total[b] | Procurement[c] |
| Defense activities[c] | 3.1 | 0 | 2.4 | 0 | 3.8 | 0 |
| General science | 17.0 | 0 | 20.3 | 0 | 20.1 | 0 |
| Solar, geothermal electrical energy, and storage | 17.8 | 7.1 | 6.3 | 2.5 | 0 | 0 |
| Magnetic fusion | 4.7 | 0.9 | 6.1 | 1.7 | 6.1 | 2.2 |
| Nuclear | 89.6 | 10.7 | 98.3 | 15.2[d] | 94.3 | 14.6[e] |
| Environment | 13.0 | 0.7 | 12.0 | 0 | 9.5 | 0 |
| Supporting research | 33.5 | 0.1 | 34.8 | 0.1 | 37.1 | 0.1 |
| Fossil | 16.0 | 2.6 | 8.0 | 0.9[d] | 2.2[f] | 0.2[e] |
| Conservation | 18.4 | 8.1 | 12.7 | 5.0[d] | 5.6 | 2.2[e] |
| Other DOE[c] | 4.7 | 0.5 | 3.3 | 0 | 4.9 | 0 |
| DOE Total | 217.8 | 30.7 | 204.2 | 25.4 | 183.6 | 19.3 |
| Work-for-others[c] | 25.4 | 1.3 | 27.9 | 1.4 | 31.9 | 2.2 |
| Total | 243.2 | 32.0 | 232.1 | 26.8 | 215.5 | 21.5 |

[a] Budget authority (BA).

[b] Sum of operating in addition to capital equipment and construction funds (based upon DOE data unless otherwise indicated).

[c] Data taken from Institutional Plan (IP), unless otherwise indicated.

[d] Estimated procurement = $(\text{Procurement})_{IP} \times (BA)_{DOE}/(BA)_{IP}$.

[e] Estimated procurement = $(\text{Procurement})_{1982} \times (BA)_{1983}/(BA)_{1982}$.

[f] Fossil program prorated to retain 1982 market share.

### Table C.3. MPL budget[a] ($ in millions)

| BNL | FY 1981 | | FY 1982 | | FY 1983 | |
|---|---|---|---|---|---|---|
| | Total[b] | Procurement[c] | Total[b] | Procurement[c] | Total[b] | Procurement[c] |
| Defense activities[c] | 2.4 | | 2.0 | | 2.6 | |
| General science | 110.8 | | 90.8 | | 92.2 | |
| Solar, geothermal, electrical energy, and storage | 10.5 | | 6.0 | | 0.3 | |
| Magnetic fusion | 1.3 | | 1.3 | | 1.5 | |
| Nuclear | 0.7 | | 0.6 | | 0 | |
| Environment | 7.4 | | 8.0 | | 5.9 | |
| Supporting research | 27.7 | | 36.5 | | 41.2 | |
| Fossil | 2.4 | | 1.4 | | 0.4[d] | |
| Conservation | 2.8 | | 2.4 | | 0.4 | |
| Other DOE[c] | 1.3 | | 1.3 | | 0.9 | |
| DOE Total | 167.3 | | 150.3 | | 145.4 | |
| Work-for-others[c] | 31.0 | | 33.0 | | 32.4 | |
| Total | 198.3 | 45.0 | 183.3 | 33.0[e] | 177.8 | 32.0[e] |

[a] Budget authority.

[b] Sum of operating in addition to capital equipment and construction funds (based upon DOE data unless otherwise indicated).

[c] Data taken from Institutional Plan, unless otherwise indicated.

[d] Fossil program prorated to retain 1982 market share.

[e] Estimated at 18% of budget.

Table C.4. MPL budget[a]
($ in millions)

| LBL | FY 1981 | | FY 1982 | | FY 1983 | |
|---|---|---|---|---|---|---|
| | Total[b] | Procurement[c] | Total[b] | Procurement[c] | Total[b] | Procurement[c] |
| Defense activities[c] | 2.1[c] | | 2.9[c] | | 1.5[c] | |
| General science | 48.2 | | 48.1 | | 46.9 | |
| Solar, geothermal, electrical energy, and storage | 14.3 | | 9.9 | | 1.0 | |
| Magnetic fusion | 8.4 | | 8.3 | | 9.2 | |
| Nuclear | 1.2 | | 0.4 | | 0.6 | |
| Environment | 7.7 | | 5.9 | | 5.3 | |
| Supporting research | 17.3 | | 18.1 | | 20.7 | |
| Fossil | 3.1 | | 1.4 | | 0.4[d] | |
| Conservation | 6.9 | | 7.6 | | 2.5 | |
| Other DOE[c] | 0.4 | | 0.4 | | 0.4 | |
| DOE Total | 109.6 | | 103.0 | | 88.5 | |
| Work-for-others[c] | 24.5 | | 23.9 | | 19.6 | |
| Total | 134.1 | 21.0 | 126.9 | 19[e] | 108.1 | 16[e] |

[a] Budget authority.

[b] Sum of operating in addition to capital equipment and construction funds (based upon DOE data unless otherwise indicated).

[c] Data taken from Institutional Plan, unless otherwise indicated.

[d] Fossil program prorated to retain 1982 market share.

[e] Estimated at 15% of budget.

Table C.5. MPL budget[a]
($ in millions)

| LLNL | FY 1981 | | FY 1982 | | FY 1983 | |
|---|---|---|---|---|---|---|
| | Total[b] | Procurement[c] | Total[b] | Procurement[c] | Total[b] | Procurement[c] |
| Defense activities[c] | 343.3 | 35.4 | 426.6 | 49.3 | 426.0[g] | 49.0[e] |
| General science | 2.0 | | 1.8 | | 1.6 | |
| Solar, geothermal electrical energy, and storage | 7.1 | 3.4 | 2.3 | 0.4 | 0 | 0 |
| Magnetic fusion | 70.8 | 7.9 | 91.0 | 7.7 | 96.3 | 8.1[e] |
| Nuclear | 21.3 | 8.6 | 19.7 | 6.5[d] | 0.4[h] | |
| Environment | 7.2 | 0.2 | 6.2 | 0.5[d] | 5.3 | 0.4 |
| Supporting research | 4.0 | | 3.6 | | 4.4 | |
| Fossil | 7.2 | 0.8 | 6.6 | 0.5[d] | 1.6[f] | 0.1[e] |
| Conservation | 0.7 | | 0.3 | | 0.3 | |
| Other DOE[c] | 6.8 | 0.6 | 12.1 | 0.7 | 9.5 | 0.7 |
| DOE Total | 470.4 | 56.9 | 570.2 | 65.5 | 545.4[f,h] | 58.3 |
| Work-for-others[c] | 72.3 | | 72.0 | | 82.4 | |
| Total | 542.7 | 56.9 | 642.2 | 65.6 | 627.8[h] | 58.3 |

[a] Budget authority (BA).

[b] Sum of operating in addition to capital equipment and construction funds (based upon DOE data unless otherwise indicated).

[c] Data taken from Institutional Plan (IP), unless otherwise indicated.

[d] Estimated procurement = $(\text{Procurement})_{\text{IP}} \times (\text{BA})_{\text{DOE}}/(\text{BA})_{\text{IP}}$.

[e] Estimated procurement = $(\text{Procurement})_{1982} \times (\text{BA})_{1983}/(\text{BA})_{1982}$.

[f] Fossil program prorated to retain 1982 market share.

[g] Estimate based on President's budget.

[h] An additional $33 million may be awarded for Advanced Isotope Separation.

Table C.6. MPL budget[a]
($ in millions)

| LANL | FY 1981 | | FY 1982 | | FY 1983 | |
|---|---|---|---|---|---|---|
| | Total[b] | Procurement[c] | Total[b] | Procurement[c] | Total[b] | Procurement[c] |
| Defense activities[c] | 273.4 | | 340.8 | | 369.0 | |
| General science | 39.5 | | 41.7 | | 43.2 | |
| Solar, geothermal electrical energy, and storage | 6.1 | | 10.3 | | 2.8 | |
| Magnetic fusion | 20.1 | | 19.9 | | 20.0 | |
| Nuclear | 35.9 | | 35.1 | | 10.7[d] | |
| Environment | 7.1 | | 7.0 | | 6.2 | |
| Supporting research | 8.5 | | 8.6 | | 9.4 | |
| Fossil | 6.2 | | 4.0 | | 1.2[e] | |
| Conservation | 1.4 | | 1.3 | | 0 | |
| Other DOE[c] | 34.6 | | 33.6 | | 33.0 | |
| DOE Total | 432.8 | | 502.3 | | 495.5[d] | |
| Work-for-others[c] | 48.3 | | 53.8 | | 66.0[d] | |
| Total | 481.1 | 164.0[f] | 556.1 | 189.0[f] | 561.5 | 191.0[f] |

[a] Budget authority (BA).

[b] Sum of operating in addition to capital equipment and construction funds (based upon DOE data unless otherwise indicated).

[c] Data taken from Institutional Plan unless otherwise indicated.

[d] An additional $33 million may be awarded for Advanced Isotope Separation.

[e] Fossil program prorated to retain 1982 market share.

[f] Estimated at 34% of budget.

### Table C.7. MPL budget[a]
### ($ in millions)

| ORNL | FY 1981 | | FY 1982 | | FY 1983 | |
|---|---|---|---|---|---|---|
| | Total[b] | Procurement[c] | Total[b] | Procurement[c] | Total[b] | Procurement[c] |
| Defense activities | 25.6 | 4.0 | 29.8 | 4.5 | 33.3 | 3.9 |
| General science | 16.9 | 1.0 | 18.7 | 0.9 | 16.7 | 0.8[d] |
| Solar, geothermal, electrical energy, and storage | 22.2 | 12.0 | 9.9 | 6.6[d] | 0.1 | 0 |
| Magnetic fusion | 77.2 | 19.2 | 91.2 | 20.7 | 79.2 | 16.1[d] |
| Nuclear | 48.7 | 14.5 | 46.3 | 6.3 | 34.3 | 4.7[e] |
| Environment | 22.2 | 1.3[d] | 20.3 | 0.9[d] | 17.1 | 0.7[d] |
| Supporting research | 41.8 | 1.9 | 44.2 | 1.8 | 48.8 | 1.6[d] |
| Fossil | 13.5 | 7.4[d] | 11.1 | 7.6[d] | 0.9[f] | 0.4[d] |
| Conservation | 15.5 | 8.3 | 16.6 | 11.0[d] | 2.2 | 1.4[e] |
| Other DOE[c] | 9.3 | 4.4 | 15.7 | 9.3 | 10.8 | 6.0 |
| DOE Total | 292.9 | 74.0 | 303.8 | 69.6 | 243.4 | 31.6 |
| Work-for-others[c] | 79.6 | 18.2 | 53.0 | 7.4 | 56.8 | 6.8 |
| Total | 372.5 | 92.2 | 356.8 | 77.0 | 300.2 | 38.4 |

[a] Budget authority (BA).

[b] Sum of operating in addition to capital equipment and construction funds (based upon DOE data unless otherwise indicated).

[c] Data taken from Institutional Plan (IP), unless otherwise indicated.

[d] Estimated procurement = $(\text{Procurement})_{\text{IP}} \times (\text{BA})_{\text{DOE}}/(\text{BA})_{\text{IP}}$.

[e] Estimated procurement = $(\text{Procurement})_{1982} \times (\text{BA})_{1983}/(\text{BA})_{1982}$.

[f] Fossil program prorated to retain 1982 market share.

Table C.8. MPL budget[a]
($ in millions)

| PNL | FY 1981 | | FY 1982 | | FY 1983 | |
|---|---|---|---|---|---|---|
| | Total[b] | Procurement[c] | Total[b] | Procurement[c] | Total[b] | Procurement[c] |
| Defense activities[c] | 11.2 | 5.0 | 5.7 | 1.7[d] | 5.1 | 1.6[e] |
| General science | 0.3 | 0 | 0.4 | 0 | 0.2 | 0 |
| Solar, geothermal electrical energy, and storage | 25.6 | 12.8 | 13.3 | 4.6[d] | 1.7 | 0.6[e] |
| Magnetic fusion | | | 0.2 | | 0.3 | |
| Nuclear | 14.6 | 3.5[d] | 17.2 | 6.0[d] | 3.4 | 1.2[e] |
| Environment | 16.4 | 4.8 | 15.5 | 3.8 | 12.7 | 3.4[d] |
| Supporting research | 5.0 | 0.8 | 4.7 | 0.7 | 4.9 | 0.7 |
| Fossil | 3.2 | 1.7 | 2.0 | 0.6 | 0.3[f] | 0.1[e] |
| Conservation | 8.9 | 4.5 | 9.2 | 3.2[d] | 0.3 | 0.1[e] |
| Other DOE[c] | 1.3 | 0.4 | 0.1 | 0 | 0.1 | 0 |
| DOE Total | 86.5 | 33.5 | 68.3 | 20.6 | 29.0 | 7.7 |
| Work-for-others[c] | 64.0 | 14.6 | 51.0 | 7.0 | 50.5 | 7.0 |
| Total | 150.5 | 48.1 | 119.3 | 27.6 | 79.5 | 14.7 |

[a] Budget authority (BA).

[b] Sum of operating in addition to capital equipment and construction funds (based upon DOE data unless otherwise indicated).

[c] Data taken from Institutional Plan (IP), unless otherwise indicated.

[d] Estimated procurement = $(\text{Procurement})_{\text{IP}} \times (\text{BA})_{\text{DOE}}/(\text{BA})_{\text{IP}}$.

[e] Estimated procurement = $(\text{Procurement})_{1982} \times (\text{BA})_{1983}/(\text{BA})_{1982}$.

[f] Fossil program prorated to retain 1982 market share.

Table C.9. MPL budget[a]
($ in millions)

| Sandia | FY 1981 | | FY 1982 | | FY 1983 | |
|---|---|---|---|---|---|---|
| | Total[b] | Procurement[c] | Total[b] | Procurement[c] | Total[b] | Procurement[c] |
| Defense activities | 402.4 | | 489.0[d] | | 536.0[e] | |
| General science | | | | | | |
| Solar, geothermal, electrical energy, and storage | 76.9 | | 44.4 | | 5.7 | |
| Magnetic fusion | 2.6 | | 2.8 | | 3.3 | |
| Nuclear | 20.9 | | 22.7 | | 12.4 | |
| Environment | 0.3 | | 0 | | 0 | 0 |
| Supporting research | 10.6 | | 11.5 | | 15.0 | |
| Fossil | 22.5 | | 13.5 | | 3.8[f] | |
| Conservation | 1.2 | | 2.4 | | 1.6 | |
| Other DOE[c] | 3.3 | | 3.5 | | 3.1 | |
| DOE Total | 530.7 | | 573.8 | | 563.9 | |
| Work-for-others[c] | 130.0 | | 150.0 | | 143.0 | |
| Total | 660.7 | 268.0 | 723.8 | 290.0[g] | 706.9 | 290.0[g] |

[a] Budget authority.

[b] Sum of operating in addition to capital equipment and construction funds (based upon DOE data unless otherwise indicated).

[c] Data taken from Institutional Plan unless otherwise indicated.

[d] Estimate based on Sandia data.

[e] Increase based on President's budget.

[f] Fossil program prorated to retain 1982 market share.

[g] 41% of total.

Table C.10. Budget impact summary for FY 1983[a]
($ in millions)

| Laboratory | FY 1981 | | FY 1982 | | FY 1983 | | FY 1983/FY 1981 | |
|---|---|---|---|---|---|---|---|---|
| | Total | Net[b] | Total | Net[b] | Total | Net[b] | Total | Net[b] |
| Ames | 18.1 | 15.6 | 18.2 | 15.6 | 17.0 | 14.7 | 0.94 | 0.94 |
| ANL | 243.2 | 211.2 | 232.1 | 205.3 | 215.5 | 194.0 | 0.89 | 0.92 |
| BNL | 198.3 | 161.3 | 183.3 | 150.3 | 177.8 | 145.8 | 0.90 | 0.90 |
| LBL | 134.1 | 116.1 | 126.9 | 110.9 | 108.1 | 94.1 | 0.81 | 0.81 |
| LLL | 542.7 | 485.8 | 642.2 | 576.6 | 627.8[c] | 569.5 | 1.16 | 1.17 |
| LANL | 481.1 | 317.1 | 556.1 | 367.1 | 561.5[c] | 370.5 | 1.17 | 1.17 |
| ORNL | 372.5 | 280.3 | 356.8 | 279.8 | 300.2 | 261.8 | 0.81 | 0.93 |
| PNL | 150.5 | 102.4 | 119.3 | 91.7 | 79.5 | 64.8 | 0.53 | 0.63 |
| Sandia | 660.7 | 392.7 | 723.8 | 433.8 | 706.9 | 416.9 | 1.07 | 1.06 |
| Total | 2801.2 | 2082.5 | 2958.7 | 2231.1 | 2797.3 | 2135.1 | 1.00 | 1.03 |

[a] Budget authority.

[b] Total budget less procurement.

[c] LLNL or LANL may be awarded an additional $33 million for Advanced Isotope Separation.

presents both "total" budget obligations and "net" obligations which are "total" less procurement. The net obligations are used primarily to support personnel.

Table C.11 summarizes the budget impacts of the nondefense programs alone between FY 1981 and FY 1983.

Table C.12 presents the DOE Controller's budget estimates for FY 1981, FY 1982, and FY 1983. Figure C.1 compares the DOE budgets of Tables C.1 to C.9 with the Controller's data; we believe the budget trends in the two sets of data are in very good agreement. Figure C.1 also shows a graphic display of the impact of FY 1983 on the net budget and the nondefense budget of each laboratory.

## C.3 Impact of the President's FY 1983 Budget on the Staffing Level of Selected DOE Laboratories

### C.3.1 Introduction

At the April 15, 1982, meeting of the ERAB Multiprogram Laboratory Panel, a request was made for an estimate of the impact of FY 1983 budget on staff levels of the DOE MPLs. The budget data provided in Sect. C.1, when combined with data on procurement and staffing in the laboratories' Institutional Plans, were sufficiently complete for staffing estimates on four of the nine Laboratories (i.e., Ames, ANL, BNL, and ORNL). The other five laboratories were not analyzed for one or more of the following reasons:

1. inadequate data on Defense programs;
2. poorly defined Work-for-Others, constituting a major share of the total program; and
3. inadequate data on procurement.

### C.3.2 Analysis

The analysis was carried out on the basis of major program elements as listed in Tables C.13 through C.16. Staffing levels for FY 1981 are reported in the Institutional Plan. After deducting the anticipated procurement in the program element, it was assumed that the number of people supported in FY 1982 and FY 1983 would be proportional to the residual operating budget. Corrections of 10 and 8%, respectively, were made for inflation in FY 1982 and FY 1983.

In some instances the Institutional Plans anticipated unusual increases or decreases in the staffing level of a program, which differed from the assumption that per person costs were constant except for inflation. In those cases the trends established in the Institutional Plan were retained in the present estimates.

Table C.11. Budget impact summary for FY 1983[a] ($ in millions)

| Laboratory | FY 1981 | FY 1982 | FY 1983 | FY 1983/FY 1981 |
|---|---|---|---|---|
| Ames | 18.0 | 18.0 | 16.8 | 0.93 |
| ANL | 240.1 | 229.7 | 211.7 | 0.88 |
| BNL | 195.9 | 181.3 | 175.2 | 0.89 |
| LBL | 132.0 | 124.0 | 106.5 | 0.81 |
| LLNL | 155.3 | 166.0 | 147.8[b] | 0.95 (or 1.16)[b] |
| LANL | 190.4 | 195.1 | 167.8[b] | 0.88 (or 1.05)[b] |
| ORNL | 346.9 | 327.0 | 266.9 | 0.77 |
| PNL | 139.3 | 113.6 | 74.4 | 0.53 |
| Sandia | 190.7 | 153.7 | 102.9 | 0.54 |
| Total | 1608.6 | 1508.5 | 1270.0 | 0.79 |

[a] Less Defense programs.

[b] LLNL or LANL may receive an additional $33 million for Advanced Isotope Separation.

**Table C.12. FY 1983 budget[a]**
**Multiprogram Laboratories**
**(Obligations in millions of dollars)**

| | FY 1981 | FY 1982 | FY 1983 |
|---|---|---|---|
| Ames Laboratory | 16 | 15 | 14 |
| Argonne National Laboratory | 234 | 221 | 183 |
| Brookhaven National Laboratory | 173 | 154 | 150 |
| Hanford Engineering Development Laboratory | 195 | 201 | 168 |
| Idaho National Engineering Laboratory | 91 | 100 | 79 |
| Lawrence Berkeley Laboratory | 111 | 102 | 86 |
| Lawrence Livermore National Laboratory | 459 | 516 | 461 |
| Los Alamos National Laboratory | 401 | 454 | 444 |
| Oak Ridge National Laboratory | 298 | 297 | 243 |
| Pacific Northwest Laboratory | 92 | 69 | 30 |
| Sandia National Laboratories | 553 | 588 | 571 |
| Savannah River Laboratory | 36 | 57 | 46 |
| Total | 2,659 | 2,784 | 2,475 |
| Major program-dedicated laboratories<br>(obligations in millions of dollars) | | | |
| Bettis Atomic Power Laboratory | 193 | 186 | 201 |
| Fermi National Accelerator Laboratory | 120 | 138 | 174 |
| Knolls Atomic Power Laboratory | 142 | 177 | 191 |
| Princeton Plasma Physics Laboratory | 106 | 130 | 131 |
| Solar Energy Research Institute | 128 | 49 | 38 |
| Stanford Linear Accelerator Laboratory | 62 | 66 | 85 |
| Total | 751 | 746 | 820 |
| University R&D funding by major program office<br>($ in millions)[b] | | | |
| Program | | | |
| Energy Research (ER) | 206 | 217 | 233 |
| Fossil Energy (FE) | 45 | 16 | 7 |
| Conservation (CE) | 18 | 15 | 8 |
| Conservation | (4) | (2) | (1) |
| Solar | (14) | (13) | (7) |
| Nuclear Energy (NE) | 7 | 5 | 5 |
| Defense Programs (DP) | 8 | 7 | 7 |
| Other | 19 | 10 | 3 |
| Total | 303 | 270 | 263 |

[a] W. S. Heffelfinger. Presented at the ERAB meeting, April 8, 1982.
[b] Estimate.

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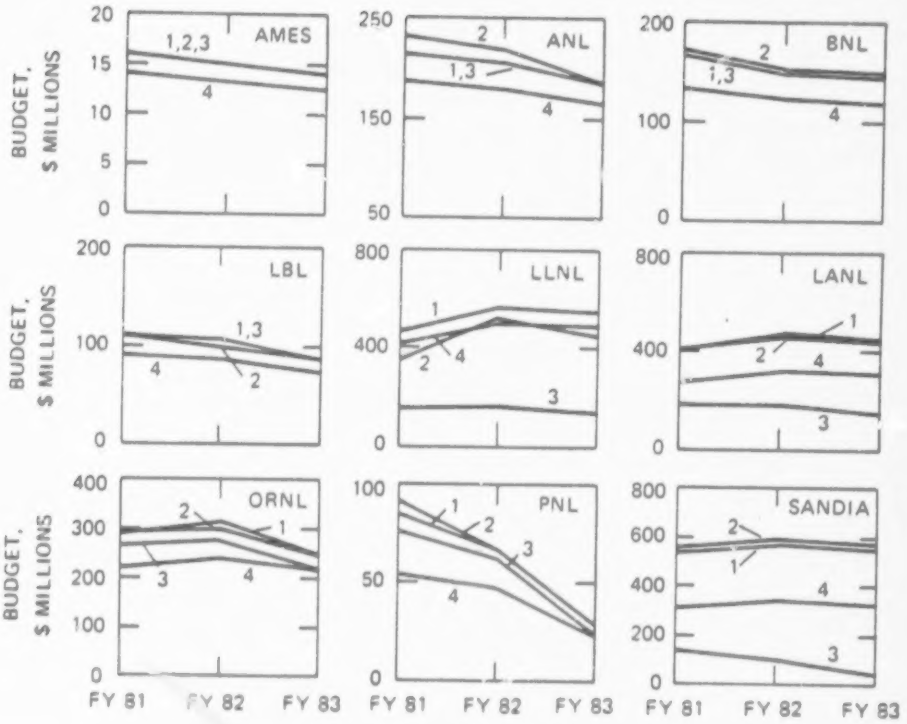

1. TOTAL DOE OBLIGATIONS, ORNL ESTIMATE
2. TOTAL DOE OBLIGATIONS, CONTROLLER'S ESTIMATE
3. TOTAL DOE NONDEFENSE OBLIGATIONS, ORNL ESTIMATE
4. DOE BUDGET LESS PROCUREMENT (NET BUDGET), ORNL ESTIMATE

Fig. C.1. Multiprogram laboratory budget trends.

Table C.13. Estimated staffing level[a]

| Ames | FY 1981 | FY 1982[b] | FY 1983[b] |
|---|---|---|---|
| Defense activities | 1 | 2 | 2 |
| General science | 17 | 14 ( 82) | 13 (76) |
| Conservation/solar | 9 | 0 | 0 |
| Magnetic fusion | 0 | 0 | 0 |
| Nuclear | 4 | 11 | 0 |
| Environment | 21 | 16 ( 76) | 12 (57) |
| Supporting research | 225 | 196 ( 87) | 196 (87) |
| Fossil | 45 | 10 ( 22) | 2 ( 4) |
| Other DOE | 0 | 0 | 0 |
| Work-for-others | 20 | 31 (155) | 16 (80) |
| Subtotal direct | 342 | 280 | 241 |
| Subtotal indirect | 137 | 112 | 97 |
| Total | 479 | 392 ( 82) | 338 (71) |

[a] Full-time equivalents.
[b] Percentage of 1981 staffing level in parentheses.

Table C.14. Estimated staffing level[a]

| ANL | FY 1981 | FY 1982[b] | FY 1983[b] |
|---|---|---|---|
| Defense activities | 32 | 22 ( 69) | 30 ( 94) |
| General science | 166 | 166 (100) | 152 ( 92) |
| Conservation/solar | 265 | 132 ( 50) | 36 ( 14) |
| Magnetic fusion | 40 | 42 (105) | 43 (107) |
| Nuclear | 845 | 801 ( 95) | 724 ( 86) |
| Environment | 199 | 176 ( 88) | 129 ( 65) |
| Supporting research | 373 | 352 ( 94) | 348 ( 93) |
| Fossil | 152 | 73 ( 48) | 19 ( 13) |
| Other DOE | 68 | 49 ( 72) | 67 ( 99) |
| Work-for-others | 249 | 271 (109) | 283 (114) |
| Subtotal direct | 2389 | 2084 | 1831 |
| Subtotal indirect | 2607 | 2274 | 1998 |
| Total | 4996 | 4358 ( 87) | 3829 ( 77) |

[a] Full-time equivalents.
[b] Percentage of 1981 staffing level in parentheses.

Table C.15. Estimated staffing level[a]

| BNL | FY 1981 | FY 1982[b] | FY 1983[b] |
|---|---|---|---|
| Defense activities | 30 | 21 (70) | 21 (70) |
| General science | 1145 | 1025 (90) | 1095 (96) |
| Conservation/solar | 138 | 79 (57) | 4 ( 3) |
| Magnetic fusion | 21 | 19 (90) | 20 (95) |
| Nuclear | 9 | 7 (78) | 0 ( 0) |
| Environment | 142 | 130 (92) | 89 (63) |
| Supporting research | 428 | 423 (99) | 423 (99) |
| Fossil | 36 | 19 (53) | 5 (14) |
| Other DOE | 14 | 13 (93) | 8 (57) |
| Work-for-others | 400 | 386 (97) | 382 (96) |
| Subtotal direct | 2863 | 2122 | 2027 |
| Subtotal indirect | 1139 | 1023 | 977 |
| Total | 3502 | 3145 (90) | 3004 (86) |

[a] Full-time equivalents.
[b] Percentage of 1981 staffing level in parentheses.

Table C.16. Estimated staffing level[a]

| ORNL | FY 1981 | FY 1982[b] | FY 1983[b] |
|---|---|---|---|
| Defense activities | 139 | 153 (110) | 168 (121) |
| General science | 140 | 142 (101) | 118 ( 84) |
| Conservation/solar | 144 | 81 ( 56) | 8 ( 6) |
| Magnetic fusion | 179 | 198 (111) | 164 ( 92) |
| Nuclear | 350 | 372 (106) | 255 ( 73) |
| Environment | 217 | 183 ( 84) | 143 ( 66) |
| Supporting research | 416 | 402 ( 97) | 414 (100) |
| Fossil | 70 | 36 ( 51) | 5 ( 7) |
| Other DOE | 29 | 34 (117) | 24 ( 83) |
| Work-for-others | 526 | 456 ( 87) | 437 |
| Subtotal direct | 2210 | 2057 | 1736 |
| Subtotal indirect | 2863 | 2665 | 2249 |
| Total | 5073 | 4722 ( 93) | 3985 ( 79) |

[a] Full-time equivalents.

[b] Percentage of 1981 staffing level in parentheses.

The staffing projections of Tables C.13 through C.16 show declines from FY 1981 to FY 1982 of 6 to 21% and from FY 1981 to FY 1983 of 14 to 29%. The projections probably overestimate the declines in staffing for the following reasons.

1. The laboratories will probably make strong efforts to attract additional Work-for-Others.
2. Congress will probably grant additional funds in some areas.
3. The laboratories will probably carry some funds over from FY 1981 into FY 1982 and FY 1983, thereby stretching out program support.
4. Program managers who currently plan to contract with the private sector may change their plans later.

Looking at specific program areas, the Physical Sciences are relatively stable. The Environmental (Biology) staffing is reduced each year at each laboratory from 10 to 25%. Conservation, Solar, and Fossil areas are nearly eliminated by FY 1983. Nuclear, which is important at ANL and ORNL, shows reduced support in FY 1983. Work-for-Others is especially important at BNL and ORNL; we have relied on data from the laboratories which project a relatively stable trend.

# APPENDIX D

# THE PNL EXPERIMENT*

T. J. Wilbanks

## D.1 Introduction

In a sense, each of our national laboratories is an experiment. Its origins and history are in some ways unique, and as a result its patterns of operation and work are a little different from any of the others. Many people believe it is now time to try to take advantage of these experiments, perhaps to transfer a few good ideas from some of the laboratories to others to help preserve the quality of the national laboratory system and to increase the usefulness of the laboratories in the 1980s and beyond.

As a contribution to the effort by the Energy Research Advisory Board Panel on national multiprogram laboratories (MPLs) to learn from the Department of Energy (DOE) laboratories as experiments, this report is a description of the distinctive "hybrid" management approach of the Pacific Northwest Laboratory (PNL) in Richland, Washington, operated for DOE by the Battelle Memorial Institute. This particular institution has been of particular interest because (1) it seems to offer certain advantages in encouraging interactions between energy laboratories and private industry and (2) it may offer additional advantages in adapting to a reduction in DOE R&D support for the energy laboratories.

This section will begin with an executive summary of the key points made in later sections. It will then summarize the origins of the PNL model; its key elements; its benefits and costs to PNL, Battelle, DOE, and its region; and some issues in contemplating a transfer of the model to other laboratories.

## D.2 Executive Summary

PNL developed its special character because of the determination of the Atomic Energy Commission (AEC) during the early 1960s to buttress the local economy in the Hanford area. With this objective in mind, it sought new contractors for separate segments of the original Hanford Project who would invest their own resources in diversifying the local economy. As an incentive for bidders for the Hanford Laboratory, one of the segments, it offered to make government-owned facilities available for private use by the contractor. The successful bidder, Battelle Memorial Institute, committed itself to a substantial investment in diversification activities [i.e., program development of different types from those previously supported by the AEC, including the development of privately funded research and development (R&D) projects].

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*The interpretations in the report are the author's. They are not necessarily representative of the views of PNL, Battelle Northwest, or DOE.

To fulfill this commitment, Battelle has created a "consolidated laboratory" in Richland, in which a DOE government-owned, contractor-operated (GOCO) national labaoratory and a nonprofit private R&D organization share facilities and people. Within this framework, government property and national laboratory staff can be used to conduct private R&D for industrial firms. To avoid charges of conflicts-of-interest, this approach requires detailed accounts of the use of staff and facilities, along with a procedure for DOE reviews of proposals for private work.

The PNL model has proved to be an effective way for a national laboratory to work closely with industry, but it is not a simple answer to the problems of other national laboratories. Along with its benefits come certain costs and complications. As a result, the attention and interest that the model deserves should be balanced by considerable caution about transferring it elsewhere.

## D.3 Origins of the PNL Model

The special character of PNL is mainly a consequence of its location. To produce plutonium for nuclear weapons, the Hanford Project was created by the federal government during the early 1940s in an isolated part of eastern Washington, along with a company town, Richland. By 1963 the need for continuing plutonium production in the United States had largely ended, and the Richland area was facing a "bust" after its 20-year boom. Together with local community leaders and the Hanford contractor, General Electric, AEC decided to take some actions to undergird a regional economy for which it felt partly responsible.

The basic idea was to divide the Hanford Project into parts and to enter into a separate operating contract for each part. Each new Hanford contractor would be expected to contribute to diversifying the economy by investing in other activities in the local area as well as performing management services for the AEC. The key words, still a part of the mystique of PNL, were segmentation and diversification.

As one step in putting an idea into effect, in March 1964 AEC issued a request for proposals (RFP) to manage and operate the Hanford Laboratory. In part, the RFP said:

> "A prime objective in requesting proposals for operation of the Laboratory under a separate contract distinct from other AEC contract activities in the Hanford Complex is the stimulation of the Tri-City area economy through permitting the Laboratory operator to solicit research and development supported by private organizations and other Government agencies. To this end, the laboratory facilities would be made available for use by the operating contractor for work of his own account on the basis of full cost recovery to the AEC.
>
> An important consideration in the selection of the contractor will be his willingness to invest private capital and/or fees earned under the contract in privately owned, research and development type facilities in the Pacific Northwest Area."

The list of selection criteria repeated this last consideration. The initial contract was to be for a five-year period, with the contractor fee negotiated annually. Unlike the competition for other segments of the Hanford complex, only not-for-profit R&D organizations were eligible to submit proposals for the Hanford Laboratory.

The winner of this competition, of course, was the Battelle Memorial Institute (BMI) — a not-for-profit institution with a charter, according to the bequest which established it, to advance knowledge for the benefit of mankind through the process of research and other creative scientific activities and to utilize that knowledge to improve the quality of life. In its proposal, Battelle promised "to commit substantial resources of its own," including reinvesting the net fee from the management contract in laboratory and regional development. The new operation contract went into effect on January 4, 1965.

Battelle took over an operation that was all-AEC in the ownership of facilities and support of people: ongoing programs, working reactors, and about 1950 employees. It immediately established a Pacific Northwest Division of Battelle (BNW), renamed the laboratory PNL, and began to invest its own money in office space and other new buildings. At the outset, $5 million of Battelle funds were committed to program and facility development, not counting the fees reinvested, and diversification was established as a principal objective (as recently as March 1981, PNL was still preparing a semiannual report on diversification activities to the Richland Operations Office of DOE). Part of the effort was devoted to developing proposals for non-AEC R&D, as invited by the RFP, and the private use of PNL personnel facilities and personnel began to grow.

The Laboratory's early history was affected by two events. One was the decision by the AEC in 1970 to transfer Fast Flux Test Facility (FFTF)-related work from PNL to Westinghouse, removing from the Laboratory its largest single activity (more than half of its space and about 1000 of its staff) and reducing it to its smallest size in many years. One response by Battelle was to invest still more of its own funds in diversification. The second event was a court decision in 1974 that placed some constraints on BMI's use of its funds; for Battelle's R&D activities, including BNW, the perception of many of its staff is that this converted the institution from a "rich" one, relatively generous with internal R&D support, to a "poorer" more parsimonious one. The promise to reinvest the fees from operating PNL, for instance, was replaced by a more general promise to contribute to the development of the region.

### D.4 Key Elements of the PNL Model

From these beginnings, emphasizing diversification to benefit the Hanford area and — toward this end — authorizing the Laboratory's contractor to make private use of laboratory facilities, PNL developed some truly unique management arrangements. Most important are (1) the "consolidated laboratory agreement" and (2) its principle enabling device, the "use permit." This section will describe these and other elements of the PNL approach.

### D.4.1 Consolidated laboratory agreement

In Richland, Washington, two different institutions share the same facilities and people: PNL, a DOE GOCO national laboratory, and the Richland activities of the Pacific Northwest Division of BMI, a not-for-profit private R&D organization. Together, they represent a staff of about 2600 people, with a PNL budget of about $140 million a year and about $24 million a year in additional R&D through Battelle. Not all facilities are shared; for example, DOE excludes utilization facilities (critical assemblies and reactors) unless their use is expressly permitted and Battelle obtains a license for that purpose from the Nuclear Regulatory Commission. These facilities are treated like any other licensed facility. But, in general, the two institutions are consolidated into one for normal operation, sharing the same organizational structure and image.

This, of course, raises some obvious questions about conflicts of interest. Are people doing Battelle work and charging DOE projects? Is DOE money being used to develop capabilities that BNW can then use to acquire support for private work? To answer such questions, the consolidated laboratory keeps detailed books on the use of people and facilities, including hourly time cards for all research staff. These accounts are carefully audited and, as a rule, any uncertainties are resolved by charging the person's time and facilty use to Battelle rather than DOE.

Most of the activities of PNL/BNW are still supported by DOE, but more DOE work is now being done in BNW facilities than the converse. In FY 1981, for instance, about three-quarters of the funding for the consolidated laboratory came from DOE, and about 80% of the staff full time-equivalents were allocated to DOE projects. But BNW privately owned space in Richland nearly equals DOE-owned space assigned to PNL. Since Battelle arrived upon the scene, only one new DOE building has been constructed; this building, first proposed before 1965 and approved by federal government in FY 1967, was completed in 1970. BNW, on the other hand, has added about 400,000 square feet of office and laboratory space at the Richland site, plus space in Seattle and at its Marine Research Center in Sequim, Washington.* In some years during the 1970s, BNW spent nearly as much money on equipment purchases for the consolidated laboratory as did DOE.

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*Considerable space is also leased for PNL activities, both by DOE and BNW. PNL staff generally prefer to work in BNW-owned facilities, which tend to be newer, cheaper, and closer to town.

### D.4.2 Use Permit

As outlined in the original RFP, BNW is allowed to use DOE facilities to perform private R&D, subject to reimbursement of DOE costs.* In principle, in such a case Battelle is considered to be a temporary "borrower" of excess capacity in government facilities for the purpose of operating a private business. The only restrictions are that (1) such uses not be incompatible with DOE programs and (2) the borrowing not interfere with PNL's work for DOE or other onsite work for DOE.

The formal specifications of this arrangement are laid out in a use permit, issued by AEC as a part of the original operating contract and since revised by memoranda from AEC and DOE. The agreement differentiates between "Contract 1830" work — work for DOE as a national laboratory — and BNW work for other sponsors (including private ones) under the "Use Permit 1831" [at PNL/BNW, the numbers 1830 and 1831 are widely used as a kind of shorthand for DOE (and conventional Work-for-Others) vs other R&D, respectively]. Among the provisions of the Use Permit is a requirement for the kinds of accounts and records mentioned above, a requirement that all facilities and personnel be made immediately available to the United States government if needed in an emergency, and a set of arrangements enabling the government (i.e., Richland Operations Office of DOE) to make sure that no conflicts of interest, incompatibility, or potential interference with DOE work are involved.

When BNW wishes to use DOE facilities for private R&D, it notifies the Richland Operations Office in writing, providing a brief statement of work, the sponsor's name and address (this information may be withheld if the sponsor specifically requests confidentiality), the facilities and equipment to be used, level of effort and time period of work, estimated funding level, security considerations, etc. If the government does not object within 15 days after receiving the notification, BNW is free to start work. Upon request, BNW is usually able to get a quicker response from the Operations Office, but the government also has a right to extend the review period if it needs further information or clarification.

When such proposed R&D is accepted by the private sponsor, the Operations Office is again notified, and the description of the R&D is confirmed or revised as appropriate. Thereafter, BNW provides the Operations Office with monthly reports on the use of government-owned property for Use Permit work.

Use Permit reimbursements amount to a revenue item for DOE of between one-half and one million dollars a year. Table D.1 lists BNW payments to DOE in recent years.

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*In fact, in order to avoid the appearance that the government is providing a cash-flow subsidy to Battelle, BNW deposits the estimated weekly cost of such work in the government's account in advance.

Table D.1. Use Permit reimbursements to
United States government
($ in thousands)

| FY | DOE-owned buildings | Service assessment added factor | DOE-owned equipment[a] | Total |
|---|---|---|---|---|
| 1976 | 361 | 155 | 79 | 595 |
| 1976-TQ | 57 | 30 | 20 | 107 |
| 1977 | 278 | 123 | 124 | 525 |
| 1978 | 240 | 111 | 178 | 529 |
| 1979 | 339 | 134 | 87 | 560 |
| 1980 | 404[a] | 171 | 104 | 679 |
| 1981 | 576[a] | 210 | 120 | 906 |
| Total | 2255 | 934 | 712 | 3901 |

[a] Calendar year amounts prorated.
Source: Battelle Northwest.

### D.4.3 Other aspects of the PNL model

Several other aspects of PNL/BNW operation are of interest as well:

**D.4.3.1 DOE work in BNW facilities.** A considerable portion of PNL's R&D for DOE is conducted in facilities owned by BNW, using equipment owned by BNW. In such cases, the only differences from using DOE facilities are that DOE reimburses BNW costs and the overhead charges are different. For example, buildings and utility costs are much lower in BNW space than DOE space.

**D.4.3.2 BNW work in BNW facilities.** When BNW proposes to conduct non-DOE work in its own space in the consolidated laboratory, it follows the use permit procedure, notifying the Operations Office of its intent and giving the government a chance to object on such grounds as incompatability with DOE interests. Operating as a consolidated laboratory, with a common staff, BNW has scrupulously tried to avoid any situation that may offend its major sponsor, DOE.

**D.4.3.3 Group research projects.** An innovation by the BMI is the group research project, in which a proprietary research effort is undertaken, supported by shares sold to industrial sponsors who thereby get access to the results.* PNL/BNW has initiated several such projects; examples include studies of high-burnup fuel effects, fuel densification, and a current project on steam generator failures. Typically, these projects are either reviews of the state of the art (quite small) or very specific applied R&D efforts directed at a well-defined general technology problem for industry (usually phased, with the early phases relatively inexpensive to the shareholders). The efforts of the first type are seldom large, stable, or highly interesting technologically. The second type may be more challenging technologically; typically, it might require a funding level per participant of $250,000 per year for five years, supported by five shareholders (several of them consortia of individual firms). Results are released to the public only after an agreed-upon delay. BNW sees this as an important option for working with industry, especially when the Laboratory faces cutbacks in DOE programs, but such projects are difficult, expensive, and time-consuming to put together. Besides the costs of contacting many potential participants, such issues as potential antitrust actions must be resolved before the group takes shape, and it should be noted that proposals for group projects seem to fare better in some fields (e.g., power systems operation) than others (e.g., biotechnology, where private firms are extraordinarily interested in keeping patent rights to themselves).

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*In some cases, DOE has itself purchased a share.

D.4.3.4 **Overall work for industry.** In the 17 years since the PNL model was created, Battelle's work at Richland for industrial sponsors has grown slowly but steadily. Since BNW figures classify as "Industrial" all Richland work not funded by the federal government, and figures for "Work-for-Others" include other federal agencies than DOE, it is difficult for an outside observer to determine the precise amount of industry-supported R&D. According to summary tables, conventional Work-for-Others accomplished under the 1830 contract (i.e., as a national laboratory) totaled about $35 million in FY 1981, and BNW work under the use permit amounted to about $25 million. It appears that more than half of this latter amount represented industry funding. Even though this level is relatively small compared with DOE support (about $110 million), getting to it has not been easy, and the results are not everyone's cup of tea. BNW leaders emphasize that (1) developing this work required a contractor familiar with industrial R&D, aware of industry needs and R&D support practices (Battelle Memorial Institute has its own industrial R&D base); (2) it also required substantial in-house support for program development and marketing, well in advance of the fruition of proposals; and (3) it required a genuine interest in doing the kinds of tasks industry wants: generally small, short-term efforts for very specific purposes. From their experience, industry is not a promising source of support for relatively basic research at national laboratories. Initially, industrial firms were somewhat suspicious of the PNL/BNW hybrid, questioning its ability to preserve confidentiality and private patent rights — and its commitment to deliver the kinds of products they wanted to pay for: simple, inexpensive results *using* the state of art, not expensive results *expanding* it. With a track record now established, the former concern has largely disappeared, and the latter has become more of a problem for the Laboratory (attempting to compete in markets with less elaborate, special purpose firms) than for the industry clients.

**D.4.3.5 The PNL model and retrenchment.** BNW managers believe that their management approach is an advantage in a time of retrenchment at national laboratories. The most obvious reason, the greater ease in seeking industry funding, is one factor in this, but from BNW's point of view the strongest reason is that many PNL staff get acculturated in entrepreneurship and a market orientation (see D.4.3.6). Perhaps they are readier than other laboratories to proceed on a basis that the responsibility for maintaining institutional support at PNL is BNW's, not DOE's.* In 1970 when the Laboratory shrank dramatically because of the loss of FFTF, BMI supplied financial support to keep things together (on the order of one million dollars a year for several years), but BMI was "richer" then. Such internal support for PNL is not anticipated in the 1980s.

**D.4.3.6 Patent rights.** For DOE work, issues concerning patent rights are resolved in the same way as any other DOE laboratory. For private work funded by industry, the sponsor of the work retains the rights to any patents that may result, unless unreported data developed by PNL staff in their DOE projects was necessary for the invention (in such a case, the government retains a non-exclusive, irrevocable, royalty-free license for the invention). If a BNW staff member has an idea for a patentable device — not conceived in performing DOE work — he/she may submit a proposal to the Battelle Development Corporation, which holds and licenses Battelle patents. If this corporation, a division of BMI, agrees that the idea is promising, it may provide R&D support for the project. In such a case, Battelle then keeps the patent. But it is Battelle policy to keep patenting and licensing (for the most part) organizationally separate from R&D. These distinctions are clear and well understood, but there is a potential for complications to arise when a person is working on both DOE and private projects during the same period.

## D.5 Benefits and Costs of the Model

Such an approach to operating a national laboratory is intriguing, but it is far from simple in practice. This section will summarize what appear to be the major benefits and costs of the approach to the Laboratory (PNL), the contractor (BMI/BNW), DOE, and the host region.

### D.5.1 Benefits and costs to PNL

In general PNL seems to be well adjusted to its management arrangement, but its research environment is different because of it.

**D.5.1.1 Benefits.** The major benefit for PNL, clearly, is its relative freedom to enter into agreements with private industry for sponsored R&D. Unlike any other DOE laboratory, it can use government-owned facilities to conduct proprietary R&D for industry, and it can use substantial facilities and equipment owned by its contractor, Battelle, for this purpose. In addition, wearing their BNW hat, the staff can respond to RFPs (generally not RFPs from DOE, but in some cases RFPs from other DOE contractors). And in times of retrenchment, such as in 1970, they may be able to get special program development support from Battelle.

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*On the other hand, institutional planning is probably more difficult when a laboratory works for a wider variety of sponsors and more of its R&D consists of small, short-term tasks.

D.5.1.2 **Costs.** The major cost is the intricate accounting system (including the cost of the support personnel and equipment to keep track of it) and an associate loss of flexibility in the allocation of resources. The detailed books, time cards, etc., make it extremely difficult to use DOE funds in discretionary ways; for instance, overhead charges against DOE projects seldom include any items not directly required for the conduct of government work. More general staff and program development resources must be found elsewhere. But, since Battelle is itself trying to keep its overhead rates down in order to compete in private markets, such resources are scarce on the BNW side as well.

D.5.1.3 **Other implications.** One consequence of this lack of flexibility (most other DOE laboratories would consider it a serious additional cost) is that PNL has developed a different style of management, much more like a private contract R&D organization than the other national laboratories. It operates more like a business, emphasizing marketing and entrepreneurship. It talks in terms of clients and products. It tends to organize itself according to markets rather than technical disciplines. It believes that developing intellectual property is seldom an attractive business proposition because this property cannot be counted upon as an important source of income; thus, it invests very little in it.* As a result, the R&D environment is considerably different from that of an institution more oriented toward gap-filling, long-term, high-risk research.

### D.5.2 Benefits and costs to Battelle

BNW staff are quite convinced that PNL has not been a money-maker for Battelle, and the evidence tends to support them. Over the years, BNW operations under the use permit have probably lost money, on balance, but Battelle has roughly broken even in its overall activities in the Pacific Northwest. PNL now pays its own way on a year-to-year basis, although it certainly did not in its early years.

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*Commenting on the draft version of this paper, PNL says: "A laboratory's ability to recover the costs of independent research and administration of licensing activities should be considered high risk investment in view of the low rate at which inventions are successfully commercialized and the very long time periods required for commercialization even of successful inventions."

**D.5.2.1 Benefits.** The tangible benefits to Battelle from the PNL relationship are relatively modest. It receives an annual fee and payments for the use of its facilities and equipment by R&D sponsors, including DOE. A little less tangibly, this R&D activity also helps to support a sizable laboratory research staff and complex of facilities, available for work on a variety of Battelle projects; and the involvement with PNL has expanded and diversified BMI as a whole. A part of the benefit, however, seems to come from the contribution of the PNL effort to the rather idealistic objectives of BMI as an institution: (1) putting research to use to help improve the quality of life and (2) assisting in the development of the region (see below).

**D.5.2.2 Costs.** Battelle has invested a great deal in BNW. In the 1965-1974 period, the total level is estimated to have been in excess of $40 million, including the reinvestment of annual fees. These investments covered start-up activities, BNW facilities in the Northwest, and program development support, including the costs of building relationships with sponsors in the distant AEC. Since 1974 PNL has been a break-even proposition, at least in principle, but it appears that a very long time will be required to repay Battelle's initial investment fully.

### D.5.3 Benefits and costs to DOE

To DOE, the implications of the PNL model are less striking than for PNL itself or Battelle, but there are some possible benefits and costs worth noting.

**D.5.3.1 Benefits.** Although it is hard to document the benefits from it (other than by a list of examples that seems to resemble the experience of other laboratories),* the PNL/BNW consolidated laboratory arrangement provides a link with industry that is unique among the DOE national laboratories. It allows industry to develop and acquire technology on a paying basis, using capabilities developed with public R&D support, and the PNL/BNW experience in working with industry can help in transferring technology from industry to government as well. A strong argument can be made that DOE derives considerable benefits from having at least one laboratory with this kind of bridge to the world of proprietary industrial R&D (and this kind of orientation toward "markets" for energy-related R&D more generally). DOE also gets the Use Permit reimbursements, which aid in getting full value from facilities that would otherwise be less fully utilized; and it receives some indirect benefits from BNW's support for the region (including its educational activities), which helps in maintaining a pleasant working environment for employees at other DOE facilities in the area.

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*Some of the examples, such as the transfer of AEC technology to Exxon Nuclear, appear to be unique to PNL/BNW, but it it not clear that they would not have occurred without the consolidated laboratory arrangement. The primary impetus seems to have been the AEC/Battelle emphasis on diversification and regional development, not the hybrid management framework.

**D.5.3.2 Costs.** The main disadvantage for DOE is the administrative complexity of the operation, together with a certain vulnerability to charges of conflicts of interest. Unquestionably, the Richland Operations Office is faced with a ticklish job, assuring that Battelle is not gaining any kind of institutional advantage because of the consolidated laboratory arrangement. Because of the long experience of its staff and the relative stability of the relationship, the Operations Office is able to conduct its audits and reviews with only three full-time people, but for a newer situation, a larger laboratory, or a less scrupulous contractor, the administrative requirements would be much larger. So far, the PNL model has resulted in no major flaps about improprieties, which is a major achievement, but the potential still exists for legal challenges and other kinds of expensive wrangles.

**D.5.3.3 Other implications.** Another implication of the PNL model (which could involve some costs) is that PNL has become largely an applied, problem-solving institution, oriented toward short-term markets for R&D. This appears harder to reconcile with DOE's current view of the role of national laboratories than most other laboratory "personalities," and it suggests the possibility of a tendency toward institutional schizophrenia at PNL in the future, with a widening split between their work for DOE and their work for industry.

### D.5.4 Benefits and costs to the region

The one clear winner is the region. PNL/BNW has diversified and grown as a consolidated laboratory, more than doubling its staff size since 1970 and providing an important continuing source of employment for the region. As a part of BMI's original commitment to the region (and of its general institutional policy, kept solidly in place by court interpretations of the Battelle request, of contributing to the quality of life of its surrounding area), BNW also provides a number of kinds of direct support to the region. For example, staff members are prominent in community organizations. Besides support for the United Way, Battelle also contributes financial support directly to community organizations and activities in the area, totaling about $150,000 a year. And Battelle was one of the founders — and supplies more than half of the faculty — for the Joint Center for Graduate Study in Richland, an educational center operated jointly by the University of Washington, Washington State University, and Oregon State University. In a rather remote region with a narrow economic base, this kind of assistance is extremely important, as the AEC foresaw in 1964.

## D.6 Issues in Transferring the Model

At least two kinds of issues are raised by the possibility of transferring the PNL model — the consolidated laboratory, the User Permits, and other practices — to other DOE national laboratories:

(1) the interest of potential contractors in playing a Battelle-type role and (2) the possible need for supplementary practices if most of the benefits are to be transferred without some of the costs.

### D.6.1 Finding contractors

It is highly questionable whether any competent R&D firm, profit or not-for-profit (including Battelle), would be interested in an agreement very much like the one that began PNL/BNW. The prospect of a large front-end investment in speculative new activities, coupled with highly uncertain cost recovery, is not at all attractive.

On the other hand, it could be argued that the current situation is quite different from 1963 and 1964 in eastern Washington. Rather than expecting a new contractor to invest in new facilities as a boost for economic development, the more likely objective would be for the contractor to purchase existing facilities from DOE, shifting capital stock to the private sector and providing revenues for the federal treasury. In exchange, the new contractor would receive some kind of User Permit for the facilities that remain government-owned. One can imagine an RFP of this sort that would attract appropriate bidders.

But a number of issues would need to be resolved. For example: (1) establishing criteria for evaluating proposals (others would certainly be required besides the highest dollar bid, since the management role is so complex and delicate); (2) deciding whether to open the bidding to profit-making firms (conducting private R&D in government facilities for profit might be more controversial than nonprofit R&D); (3) determining whether or not multiyear commitments of R&D support can be offered by DOE (this would reduce the risks to a contractor during the start-up years); and (4) perhaps responding to concerns from Battelle about equity (why should somebody now get a sweeter deal than the one they accepted in 1964?).

### D.6.2 Supplementary practices

Another class of issues would concern the costs of the PNL model to a laboratory other than PNL: particularly the added accounting requirements, the likely reduction in their flexibility in using resources, and the possible shift of the institution toward a highly market-oriented contract R&D mode. There seems to be no way around the accounting requirement, given the potential for suspicion that government money and facilities are being misused; but the other disadvantages would be ameliorated, if not entirely removed, by providing the laboratory with a dependable source of discretionary R&D support — sufficient to cover the kinds of idea development, staff development, and program redirection efforts that are needed to maintain national laboratories as top-flight institutions for long-term, high-risk R&D and centers of other expertise needed by DOE. DOD experience suggests that this might be on the order of 10 to 15% of the value of task-order funded government R&D work.* With such support, a laboratory could retain — or even increase — the flexibility that would otherwise be lost with the change in management approaches. And the situation would be more attractive to potential bidders, because their own budget would not have to bear the entire burden for program development and other nontask-order activities.

## D.7 Overall Appraisal

The PNL model is indeed a novel approach to the problem of building more effective relationships between a national laboratory and private industry, although this was not really its original purpose. It appears to be working well, and PNL/BNW has developed a considerable amount of pride in its distinctiveness. Perhaps most astonishing, it has sustained itself through a period in American history when we have seen unprecedented suspicion and skepticism about government — private-sector cooperation.

But the model is not a simple answer to the general problem of facilitating laboratory interactions with industry. It is highly complex in operation. Under the current rules of the game, it drives a laboratory toward a short-term problem-solving contract R&D mode that seems inconsistent with current Administration views about the primary roles of national laboratories. And it seems to require a remarkable kind of contractor: not only patient and — at least in the beginning — generous with internal financial support but also more than a little altruistic in motivation. All of these complications derive from an involvement in private R&D industry that amounts to less than 10% of the total activity of the PNL/BNW consolidated laboratory.

As a result, although DOE should certainly try to learn from the PNL experience, it should proceed with caution in contemplating any transfers of the model to other laboratories.

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*Such support could transform the working environment at PNL as well.

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# APPENDIX I

# AMES LABORATORY

## I. DIRECTOR'S OVERVIEW

### The Role of the Ames Laboratory

The Ames Laboratory's role is to conduct basic research addressed to correcting deficiencies in our understanding of the physical, chemical and materials sciences which underlie energy generating and other technologies essential to national interests. The Laboratory will execute this work not merely to add to our storehouse of knowledge or as an end in itself, but so that it can contribute (along with the other National Laboratories, Universities and Industry) to the continuing achievement of national goals.

The Laboratory will carry out fundamental work, especially in materials and chemical sciences, to support energy technologies that may reasonably be foreseen in the intermediate to long-range regime (i.e., 15-30 years in the future), will pursue novel, "high risk-high payoff" solutions to problems associated with these technologies, and will conduct energy related, intermediate-range applied research through the proof of technical soundness.

The Laboratory will continue to use its traditional strengths in materials preparation, chemical analysis, chemical sciences and materials sciences as well as its recently established expertise in nondestructive evaluation (NDE) to conduct the long-term basic and intermediate-range applied research needed to solve the complex materials problems encountered in energy production and utilization.

The Laboratory will maintain its internationally recognized capability for preparing ultra high purity and well-characterized metals, alloys, compounds, and single crystals and will continue to make these materials available to other DOE Laboratories, and when appropriate, to universities and the private sector.

The Laboratory will continue to cooperate with Iowa State University in the training of new scientific and engineering professionals (for both academia and industry) by appointing graduate students and postdoctoral associates to positions having direct involvement in its research programs. Thus, the Laboratory will help to regenerate that element of scientific personnel upon which it and similar institutions depend.

The Laboratory's role differs from the general university research role in that the Laboratory will conduct mission-oriented, interdisciplinary and collaborative research whereas universities tend to more effectively pursue projects that are aligned with the academic interests of single investigators. The Laboratory's role differs from that of industrial research entities because the Laboratory conducts open research that is unlikely to support a viable commercial enterprise within 5-10 years, whereas industrial research and development is usually directed toward proprietary projects which have high potentials for commercialization in 5 years or less.

While the Laboratory's research role is distinct from those of universities and industry, the Laboratory will beneficially interact with both communities. Laboratory-university interaction is achieved in a variety of ways; the most effective and mutually beneficial of these is the relationship enjoyed with Iowa State University, the institution which serves as the contractor for the Laboratory and upon whose campus the Laboratory is located. Simultaneous with their activity on Laboratory programmatic research teams, nearly all of our principal investigators hold faculty appointments at Iowa State; thus many of the University's departmental units enjoy an involvement with the forefront research conducted at the Laboratory and their students, both graduate and undergraduate, reap the benefits of interactions with professors whose academic pursuits are influenced by the vitality which results from conducting projects of national importance and broad technical relevance. The Laboratory will interact with industry by continuing to bring the processes, inventions and ideas that emerge from Laboratory research to general industrial attention and by working with specific industrial groups in the transfer of pertinent technology.

The strengths of the Ames Laboratory, its role as a national multiprogram laboratory, and the nature of certain generic problems which bear upon energy production, permit the description of some of the Laboratory's long-term (20 years or more) future activities. For example, the Laboratory will conduct basic research required to support the development and characterization of materials which are strong and corrosion resistant at high temperatures. Such materials will be needed for any energy technology based on the conversion of heat to electricity; fundamental thermodynamics dictates that the conversion efficiency increases as the conversion temperature increases so the need for high temperature materials for conversion devices will persist well into the future.

The Laboratory will pursue the materials, analytical, and chemical sciences which will underlie the characterization and development of structural materials suitable for and reliable in hostile environments. This work will also involve development of flaw detection and fracture mechanics science, forecasting lifetimes under varied service conditions, development of in-service testing technologies, translating this information into management strategies (e.g., accept-reject criteria in components manufacture, and retirement for cause criteria for in-service inspections). This work is vitally needed because capital costs of energy conversion technologies have come to be major fractions of the per-unit costs of energy produced. These large capital costs are, to a significant degree, the consequences of overdesign and major redundancies which are incorporated in the energy generating systems because we do not at present have an adequate scientific underpinning to do otherwise. The Laboratory is committed to the development of this underpinning.

These items are illustrative of major thrusts we expect to continue for at least two decades. Others, whose duration may be approximately this long, include fundamental chemistry of coal and coal processing and chemical speciation (identification and quantitation of compounds as contrasted with elements) especially as applied to energy processes including process wastes. Some of these are further discussed in later sections of this plan. Certainly, new visions of national needs will arise in the next two decades, and many of these will require new fundamental information in chemical and materials sciences for their realization. The Ames Laboratory expects to respond vigorously and effectively to these requirements.

Robert S. Hansen

Robert S. Hansen, Director

ARGONNE NATIONAL LABORATORY

# I. DIRECTOR'S OVERVIEW

## A. ARGONNE ROLE STATEMENT

Argonne National Laboratory is a reservoir of scientific and technical resources available for use in the best interests of the Nation. Throughout its history the Laboratory has applied these resources to a variety of problems of national importance.

The present role of the Laboratory is to apply its broad-based scientific and technical resources to the solutions of problems of energy supply, energy utilization, and related health and environmental protection. This mission is fulfilled through a broad range of activities, including work in the basic physical, chemical and biological sciences, applied energy technology development, and in environmental research and technological assessment.

### Relation to Universities and Industries

In carrying out its mission, Argonne has to work in a manner which is compatible with and complementary to other research and development institutions: universities, private industries and other national laboratories. The mission of the universities and the nature of private enterprises allow for this compatibility and complementarity with the national laboratories. There is a legitimate need and role for each type of institution. The primary mission of the university is education which uniquely distinguishes it from the other two types of organizations. Scholarly activities, including research, in universities has to be consonant with this educational mission. This implies that certain types of research are inappropriate to be carried out at universities. The profit motive of private industry distinguishes this sector from universities or national laboratories. Research and development activities undertaken by private industry should contribute sooner or later to profits; therefore, certain types of research and development, which may not be supported by the market at particular times, will not be carried out in the private sector.

Appropriate research and development work in the national laboratories has its own characteristics: (1) It is long-range, high risk, with high payoff potential, and the near-term economic payoff is minimal; thereby providing little incentive for private support. (2) It addresses questions which have national or international consequences such as large-scale health and environmental problems. (3) It requires the use of facilities either too large or too complex to be operated by a single university or industry, or sufficiently unique that federal funding is appropriate. (4) It involves issues where the role of the federal government is clearly defined, for example, national security and issues such as nuclear proliferation.

By adhering to these guidelines, Argonne bridges the gap between work done at universities and research carried out in private industry. These guidelines also support the complementary relationship among universities, private industries and the national laboratories. The educational mission of the university is enhanced through programs which bring university scientists and students to the laboratories to engage in research utilizing the unique facilities. Special workshops, summer programs, and visiting sabbatical leave programs are other means through which the laboratories contribute to the educational and research goals of the universities. Last year Argonne had more than 1250 faculty and 550 students who participated in one or more joint activities at the Laboratory.

The relationship between the laboratories and private industry is exemplified through programs of technology transfer. Technology transfer is a major responsibility of Argonne. This has been recognized in legislation, through direction from the Department of Energy, and by the establishment within the Laboratory of an organization with specific responsibility for the management and coordination of technology transfer efforts. Further, an integrated approach involving participation in national activities with other organizations is also taking place. The Industrial Research Institute and the Federal Laboratory Consortium are two such organizations. The Laboratory is also increasing its cooperation and involvement with local and regional organizations, both industrial and governmental, through sponsoring seminars, joint research efforts, and through faculty student and scientist exchange programs.

## Programmatic Goals and Relation to Other National Laboratories

Argonne's role is distinguished from those of the other multiprogram national laboratories by the spectrum of work we perform and the strengths which exist at the Laboratory. Future directions are defined to enhance the complementarity of Argonne with the other national laboratories.

Figure I-1 shows how our work is distributed, both by area and in terms of basic research to technological development.

Although there are several models and distribution of work which can lead to a healthy and vital laboratory, we believe the distribution prevailing at Argonne is logical for the Laboratory at this time. As can be seen, it consists of one major applied program with smaller applied efforts complementary to the major program, all of which is undergirded by strong basic research and base technology efforts in areas which relate to the applied work. Major emphasis at Argonne is on nuclear energy technology. Historically, the nuclear program has been the largest effort at the Laboratory. We foresee this to be the case for the intermediate future. The breeder reactor technology program will continue to be the predominant part of the nuclear program, with significant though smaller efforts in light water reactors and support of radioactive waste disposal technology. Future efforts in the fossil area will center on advanced process development, materials technology, instrumentation and controls systems engineering, to be used in advanced energy processes: gasification, liquefaction, and fluidized-bed combustion.

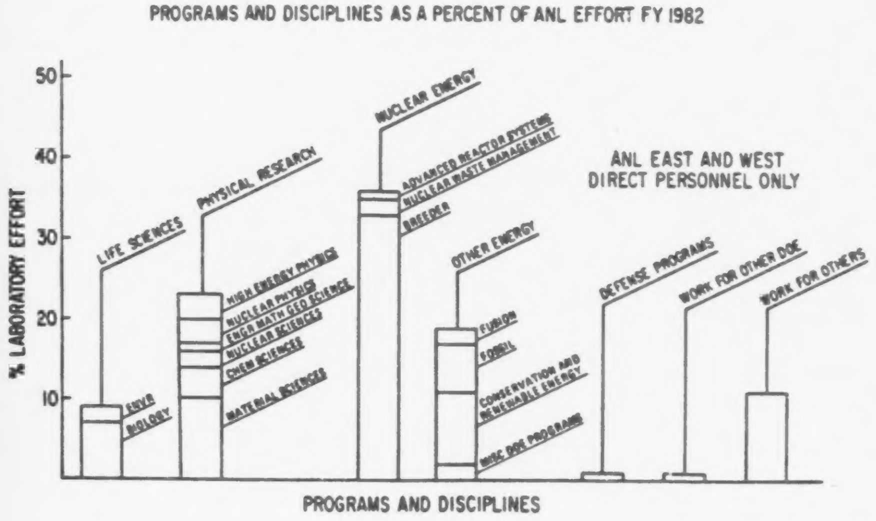

PROGRAMS AND DISCIPLINES AS A PERCENT OF ANL EFFORT FY 1982

*Figure I-1*

Applied work in solar and conservation will concentrate on innovative new ideas and concepts such as improved collectors or energy conversion systems, which may arise from the basic research in base technology programs, or which are required of the Laboratory by national need.

The consequences of the utilization of particular energy technologies, as manifested in environmental and health-related problems, are addressed through our studies on the effects of radiation, chemical agents, and other pollutants on living organisms and ecosystems. Studies in these areas are based on our unique facilities and special competence such as the JANUS reactor, IPNS, and the ISO-DALT electrophoresis system. We do not anticipate significant growth in this area, but expect to keep a strong program focused on the forefront of research efforts.

As the breeder program matures, we foresee Argonne's major applied effort as being increasingly directed towards fusion engineering and development. Given the Laboratory's background and experience in the design, development, and construction of advanced reactors and superconducting magnets, and its extensive expertise in materials and instrumentation, it is logical that the Laboratory should play a critical role in the national fusion energy program as it enters the engineering phase.

The largest effort at Argonne in basic research and base technology is in the area of general materials studies. Work is carried out in several divisions throughout the Laboratory. The study of materials is an essential effort for all of the applied activities at the Laboratory: fission, fusion, work in the fossil area, and solar and conservation. It is our intent to consolidate and strengthen our effort in materials science to better coordinate the work throughout all divisions involved. Although the basic research program will continue to be disciplinary in character in many instances, the cross-cutting theme guiding these efforts will be focused on materials science.

The national trust areas of high energy physics and nuclear physics will continue to play a significant role at the Laboratory. Work in these areas is especially important in providing facilities and expertise for scientists outside the national laboratories, in industries and especially universities. This is part of the national laboratories' mission to construct and operate major research facilities. In the nuclear physics program, the ATLAS facility will be a centerpiece of heavy ion research nationally. Work in the High Energy Physics Division will center on the design, development and construction of large instruments in conjunction with university groups. The scientific effort in these "trust" areas also relates to the mission of the Laboratory: expertise in superconducting magnet design and development, accelerator development, and electronics instrumentation reside in these areas and is critical to our applied programs.

Argonne National Laboratory is now completing its 35th year of continuous operation in the service of the country. Those 35 years have seen the Laboratory evolve from a primarily nuclear energy laboratory to one which now addresses a broad spectrum of energy-related problems. Elements of both stability and change have been part of Argonne's role and mission. As the Nation's needs change, the role of Argonne will evolve. The Laboratory's basic strength lies in the scientific and technical expertise of its people and the uniqueness and versatility of its facilities. These strengths will serve the Nation well as the research and development priorities in the future adjust to the Nation's need in the coming decade and beyond.

Walter E Massey

Walter E. Massey, Director

# BROOKHAVEN NATIONAL LABORATORY

## I. DIRECTOR'S OVERVIEW

The primary role of Brookhaven National Laboratory (BNL) is to develop and operate complex research facilities for the scientific community and to conduct research with these facilities. Such facilities are developed in response to needs of the scientific community and the interests of the Laboratory, and in agreement with the sponsoring agency (DOE). A further role of BNL is to conduct scientific research in selected technology-base and life science areas in support of the mission of its sponsor. Providing forefront research facilities means conceiving, designing, constructing, operating, and periodically upgrading large, unique devices and insuring their effective use. This requires that, besides designers and builders, a substantial complement of first rank scientists be on the Laboratory staff to make use of the facilities and to form close and continuing relationships with the outside research communities. The Laboratory's policies are designed to meet these requirements, and have demonstrated their effectiveness. An important element of these policies is the deliberate rotation of junior members of the research staff to ensure an inflow of new ideas and retention of only the exceptionally well qualified.

In fulfilling its primary role, the Laboratory is committed to continuing to provide the user communities with such unique research devices as the Alternating Gradient Synchrotron (AGS), the High Flux Beam Reactor (HFBR), the Tandem Van de Graaff, the Medical Research Reactor, etc. The two newest facilities--the recently constructed National Synchrotron Light Source (NSLS) and the Intersecting Storage Accelerator (ISABELLE) which is now under construction--are outgrowths of the expressed needs of a large community of researchers in universities, industries, and other laboratories. Each of these machines is expected to exert profound influences on the nature of the basic and applied research programs at BNL and elsewhere; they are also expected to spawn exciting and rewarding new programs whose nature cannot at present be described.

Basic and applied research programs in the technology-base areas at BNL are carefully selected to be responsive to the needs of DOE. These programs ordinarily are required to meet one or more of the following conditions:

- They are focused on long-term, high risk R&D with the potential of high payoff.
- The work requires technical competence or facilities that are uniquely available at BNL.
- The nature of the work demands objectivity and independence of proprietary interests.

In fulfilling its role of supporting national R&D needs, the Laboratory emphasizes partnership with the university and industrial sectors. It selects its technology-base research in needed activities that are beyond the capability and interest of universities or industry to perform. The viewpoints of the private sector are brought in continually through advisory committees for applied programs and visiting committees for the applied science departments. These committees include a substantial number of industrial scientists and engineers. The Laboratory's activities complement the efforts of the universities, and thus contribute to the national output of trained scientists and engineers. Approximately 1000 scientists and graduate students from universities hold non-salaried appointments and conduct research at BNL during any given year; in addition, salaried appointments are given to about 100 scientists from university faculties and to about 85 undergraduate and graduate students each summer. This interaction is of great value to both sides: the experience gained by the large number of university scientists and engineers is of value to them and, in turn, to their home institutions, and the Laboratory benefits from the continual infusion of new ideas and insights.

Laboratory management believes that history has demonstrated the efficacy of the methods by which Brookhaven has fulfilled its primary role--the symbiotic co-location of strong research programs and forefront research machines, coupled with personnel policies that ensure continual renewal of its own staff and diffusion of talent throughout the scientific community. It anticipates continuing to perform this role with essentially the same balance between its research programs and the operation of the research machines, although specific details of these two components will change in response to research opportunities and national needs.

## LAW[illegible]ICE BERKELEY LABORATORY

# I. DIRECTOR'S OVERVIEW

### THE ROLE OF THE LAWRENCE BERKELEY LABORATORY

The Lawrence Berkeley Laboratory's major role is to conduct research programs that are appropriate for an energy research laboratory but not suited to the program goals or resources of a university campus. Thus the development and utilization of large experimental facilities is emphasized, and the interdisciplinary team approach to research is stressed. Lawrence Berkeley Laboratory also supports university-based research nationwide by providing major national facilities--the SuperHILAC, Bevalac, and the National Center for Electron Microscopy--that are readily accessible to qualified investigators.

The Laboratory is unique among the National Laboratories in being effectively co-located with the Berkeley Campus of the University of California. The Laboratory serves an important national need by conducting basic research in an environment that combines academic quality and renewal with National Laboratory R&D management experience and facilities. Faculty in scientific and engineering disciplines are carefully selected to augment Laboratory staff in performing research in technology base areas chosen to advance DOE program goals in nuclear and energy research.

As a unit of the University of California, Lawrence Berkeley Laboratory has an unmatched role in the training of the next generation of scientists and engineers for careers in advanced energy research and technology. Over 500 resident graduate students conduct thesis research at the Laboratory, and many more use LBL facilities or perform collaborative research. Participation in DOE-supported energy research programs at LBL provides these students with skills in high demand by energy industries. The flow of Berkeley Ph.D.s to industry is one of many forms of technology transfer that allows Lawrence Berkeley Laboratory to maintain close and supportive relationships with industry. The Laboratory-industry boundaries are defined by LBL's focus on long-term, high-risk generic research particularly suited to the Laboratory's facilities and capabilities, which are not duplicated in industrial laboratories. At the same time, the close contact of LBL with industry ensures the relevance of its generic energy research.

The Laboratory's long-range plan for the period 1981-2000 includes the following components as elements of the LBL role.

In high-energy physics the LBL role has two major components. As a detector laboratory, LBL brings resources and skills to bear on developing detectors of the future, such as the highly-successful Time Projection Chamber, in collaboration with consortia of universities. As a resource laboratory, LBL carries out long-range research and development, as in the 10-Tesla Magnet Program, and can participate in planning the national high energy physics program.

Relativistic heavy-ion physics is rapidly evolving as the major frontier of nuclear science, and is attracting increasing interest in high-energy physics. Continued scientific advances at the upgraded Bevalac would establish a need for further exploration of this frontier by means of a higher-energy machine such as VENUS in the late 1980s.

The intrinsic advantages of heavy-ion radiotherapy and the importance of heavy-ion radiobiology are well-understood. In 1980 a proposal for a major Medical Accelerator Design Study was submitted to NIH. The proposal was funded and the study is under way.

The LBL Materials Sciences program in alloy design, mechanical metallurgy, and ceramic science are consolidating around the new National Center for Electron Microscopy. The Material Sciences and Chemical Sciences programs support LBL's pre-eminent surface science and catalysis research, while Chemical Sciences supports LBL's unique chemical dynamics and its new thrust in the use of modern laser techniques to reveal temporal aspects of photobiology and photochemistry.

In the Magnetic Fusion Energy program, LBL's success in positive-ion neutral beams has led to a long-term program in plasma heating. The emphasis has shifted to negative-ion neutral beams, and radio-frequency heating is also under study.

Several LBL programs have utilized synchrotron radiation at the Stanford Synchrotron Radiation Laboratory (SSRL) since 1974. Unique insertion devices based on $SmCo_5$ magnets have been built at LBL and installed at SSRL to produce superior synchrotron radiation sources. The Laboratory's role in synchrotron radiation research will grow in the 1980s.

The Laboratory's expertise in geohydrology addresses national needs in nuclear waste isolation and in geothermal reservoir research. The LBL group is a national resource for solving future nuclear and energy research problems in the geological realm.

The LBL Energy Efficient Buildings program is a national asset, as is the LBL Electrochemistry program. Both of these major programs fill national needs in long-range energy research and fulfill part of LBL's role.

Memorandum fm H. E. Roser to A. Trivelpiece
dtd 12/3/81

## LAWRENCE LIVERMORE NATIONAL LABORATORY
## REVISED DRAFT ROLE STATEMENT

"The Department of Energy's generic role statement, applying to all its multiprogram National Laboratories, notes that these Laboratories play three distinct and vital roles in the Nation's technological enterprise, two of which have no parallel in the private sector. One of these unique functions involves activities in support of the Nation's nuclear weapons program. The other involves research relating to the Nation's high energy and nuclear physics program. The third role is that of seeking technological remedies to the Nation's energy program. The Lawrence Livermore National Laboratory is deeply involved in two of these areas: the nuclear weapons program and the energy research and development programs.

The continuing major role of the Lawrence Livermore National Laboratory is to conduct nuclear weapon research and to design specific weapons in response to national defense requirements. This responsibility includes scientific and technical support of all facets of the nuclear weapons program. To support this role we have developed into a strong, multidisciplinary, goal-oriented, applied science laboratory capable of solving complex problems. This capability has been used not only to address defense problems, but also other relevant national problems. Such tasks are selected on the basis of synergism with our weapons program, importance to the Nation, appropriateness to our parent agency, and appropriateness to this National Laboratory. This latter criterion requires a careful analysis of whether a problem is optimally placed here on the basis of our mix of skills and facilities versus those in industry or university setting. On many of the energy technology projects, our role is one of performing multidisciplinary research in areas that fall between the interests or capabilities of the universities and industry.

The universities can, and should, do most of the fundamental research. We concentrate on goal-oriented applied research. In general, our non-weapon research is therefore characterized by large scale, long duration, high risk, multiple discipline, and complementarity to our nuclear weapons research. Now, as a natural outgrowth of national requirements and our unique strengths, about half of our efforts are devoted to the weapons role and about half to magnetic and laser fusion research, biomedical and environmental research, applied energy technology, and related research activities. Recognizing the long-range, yet constantly changing, nature of these National programs we must devote some effort to long-range planning in order to constantly evaluate major technical issues on the National level and to identify our role in these issues."

Memorandum to H. E. Roser to A. Trivelpiece
dtd 12/3/81

LOS ALAMOS NATIONAL LABORATORY

## THE ROLE OF THE LABORATORY

The role of the Los Alamos National Laboratory is to be a center of knowledge and capability in the natural sciences and engineering disciplines for the solution of national problems. The Laboratory:

- contributes multidisciplinary skills for solving national problems with particular emphasis on coupling the basic sciences and engineering disciplines with technological innovation;
- conducts basic and applied research and development in support of its mission;
- brings flexibility and continuity to long-term complex programs;
- has unique facilities and knowledge which constitute valuable resources for rapid response to urgent national needs;
- provides an interface between the frontier research carried out at universities and the applications-oriented needs of government and industry; and
- supplies the government and the public with informed and independent scientific opinion;

Memorandum fm H. E. Roser to A. Trivelpiece
dtd 12/3/81

# THE MISSION OF THE LABORATORY

The mission of the Los Alamos National Laboratory is to advance science and technology and to apply them in programs which contribute to the maintenance of a strong defense, the fulfillment of arms control commitments, and the guarantee of a secure energy supply for the future. To ensure that this mission is fulfilled, the Laboratory will maintain and enhance a vital scientific research and technology base, and remain alert and responsive to new demands for solutions to emerging national problems.

Oak Ridge National Laboratory Institutional
Plan - FY 1982-198

OAK RIDGE NATIONAL LABORATORY

# LABORATORY TRENDS AND FUTURE DEVELOPMENT

## *Laboratory Role*

The primary objective of the Oak Ridge National Laboratory (ORNL) is to support national fission and fusion energy goals through scientific research and technology development. Emphasis is on long-term, high-risk, high-payoff technology development and on generating scientific and technical data (e.g., energy-related health, safety, and environmental) that are of national importance but that lack the incentives necessary for the private sector to develop and that are unsuitable for universities because of project size or because of the need for a multidisciplinary approach requiring long-term continuity. In support of this objective, the Laboratory carries out strong base technology research programs in engineering and in the physical, environmental, and biological sciences.

Energy technology development at ORNL emphasizes the fission nuclear fuel cycle and magnetic fusion and includes important other efforts in residential and commercial energy conservation and in some areas of coal conversion and utilization. The technology areas in which ORNL participates involve high risks and long-term commitments that industry finds unacceptable. In addition to ORNL's participation in the development of major energy technologies, the Laboratory maintains occasional and lesser involvement in other technologies [e.g., geothermal, ocean thermal energy conversion (OTEC), energy storage, etc.] in which existing facilities and expertise offer unique capabilities to the Department of Energy (DOE). ORNL also serves as a technical program manager for DOE in specialized areas of technology development in which we have special competence.

Another primary role of ORNL is to identify and provide solutions to generic research problems in energy-base technologies such as materials, separation techniques, chemical processes, biological screening, and biotechnology. In carrying out this role, ORNL conducts basic research in physical and life sciences in order to provide a solid basis on which to make decisions about the various energy technology options.

The philosophy of reinforcing fundamental thrusts of a few, well-chosen technologies (multiprogram) with broad, long-term, and more basic research in a variety of pertinent disciplines (multidiscipline) characterizes ORNL in the role of a multiprogram laboratory. This role is broadened by including a few areas of more basic research in which ORNL generates, analyzes, and systematizes new fundamental knowledge by virtue of the Laboratory's stewardship of unique or rare national facilities and resources such as reactors, the National Environmental Research Park, animal research facilities, and heavy-ion facilities.

The only non-R&D role for ORNL is in the manufacture, production, and sale of radioactive and stable isotopes to the medical, industrial, and research communities. This is a function that U.S. private industry does not have the capability to provide.

The Laboratory also does work for the Nuclear Regulatory Commission (NRC) and, in areas where DOE has a program interest and facilities exist, undertakes work for other federal agencies such as the U.S. Department of Health and Human Services (DHHS) and the Environmental Protection Agency (EPA). This work for others amounts to about 20% of the Laboratory's program.

ORNL expends special effort to transfer technology to the private sector; to involve industry, where appropriate, in ORNL programs; and to encourage cooperative uses of facilities, both formally in users' groups and informally through professional contacts and participation. Similarly, the Laboratory provides universities with ready access to major research facilities and programs. At ORNL users have access to state-of-the-art research capabilities, training facilities for faculty and students, and an opportunity for collaborative research in areas in which these facilities and techniques are not available to universities.

Finally, ORNL plays a special regional role for energy-related activities in the southeastern United States by providing universities access to its facilities, engaging in energy technologies that are of interest in the Southeast, and supporting and collaborating with other institutions—state and local governments and organizations such as the Tennessee Valley Authority (TVA)—that are primary R&D influences in the area. In addition, ORNL is linked to other DOE-sponsored development activities in the Oak Ridge area, such as the Clinch River Breeder Reactor (CRBR), the uranium enrichment programs, and support to the Operations Office.

## Capabilities and Directions

ORNL has some special capabilities and facilities which promote contributions to energy development and to the growth of basic knowledge through research in most science and engineering areas. ORNL has traditionally tackled large-scale R&D problems with a high success rate made possible by maintaining within the divisions an unexcelled multidisciplinary capability. This traditional stance continues. Extensive and or often unique facilities are located close together at the Laboratory as a result of ORNL's carrying out large, multifaceted research programs over the years. The breadth in types of physical facilities and the breadth and depth of personnel training make the Laboratory an invaluable national resource.

While current research programs are not so exclusively focused on nuclear energy as they were in the past, the multidisciplinary character of the Laboratory accommodates other major problems of national importance. Some examples are the technology-specific assessments in fossil energy development and the ongoing nuclear waste disposal storage research. A recent result in nuclear waste storage research points very favorably to the incorporation of wastes in natural minerals, for example, in monazites. Another example of the advantage of a multidisciplinary problem-solving capability is the development of new or improved materials for specialized applications, namely, high-temperature materials for developing energy technologies.

Materials research is of such central importance to advanced technology development that a high-temperature materials program has been established at ORNL. The high level of DOE support for construction of a high-temperature materials laboratory (HTML) underscores the importance of this multidiscipline research program. In addition, and complementary to the HTML, an engineering science center has been proposed to help advance our knowledge of basic engineering data pertaining to heat and mass transfer, fluid dynamics, and solid mechanics. The Life Sciences Synthetic Fuels Program exemplifies the high degree of success obtainable through mission-oriented research in a multidisciplined laboratory.

Many of the research facilities at the Laboratory are mutually supportive because of their being located close to one another. For example, the fusion energy program requires data that are supplied by basic measurements in the nuclear physics facilities. Materials research depends heavily on the neutron-scattering and irradiation facilities available at the research reactors and accelerators. Fuel-reprocessing development requires the expertise of chemists and chemical technologists as well as the availability of many materials-handling facilities not found nearby or in many other locations.

Pacific Northwes Laboratory
Institutional Pla.. - FY 1982-1987

PACIFIC NORTHWEST LABORATORY

# DIRECTOR'S OVERVIEW

## Roles and Mission

Five principal roles guide our programmatic efforts:

1) research and development to resolve key nuclear issues;
2) research and engineering for support of the Hanford and national defense mission;
3) timely identification and resolution of environmental, health, and safety issues;
4) development of research bases for conservation and the technologies of fission, fossil, and solar; and
5) preparation and transfer of DOE technology for commercialization by industry.

These roles support the Pacific Northwest Laboratory (PNL) mission which is the advancement and use of multi-energy scientific and engineering technology for national security and energy needs. High priority is given to safe and reliable nuclear energy and to promising new concepts and technologies for operations at Hanford. The Laboratory's focus is on technical programs that use:

- a multidisciplinary breadth and depth of staff,
- a unique consolidation of DOE and Battelle facilities combined with a single laboratory staff for research and development,
- a core capability for effectively utilizing the strengths of the private sector and universities to meet DOE objectives, and
- an experienced, disciplined project management system to use resources effectively,
- a technical competence for independent assessments, innovative applied and fast R&D responses consistent with our resources.

This focus distinguishes our roles from those of the universities and the private sector with which we have traditionally developed and maintained strong ties. The ability to couple basic science with sophisticated technological expertise in a problem solving environment enables us to complement and bridge the outputs of universities and the private sector.

Memorandum to H. E. Roser to A. Trivelpiece
dtd 12/3/81

## Role Statement

## Sandia National Laboratories

The continuing primary role of Sandia National Laboratories is to provide a nuclear ordnance capability second to none, to develop weapons in response to defense needs and to assure that the weapon stockpile remains safe and reliable.

As DOE's largest laboratory and as an engineering laboratory with broad capabilities, Sandia also contributes to the solution of other national security related problems, principally in the field of energy and where advanced technologies are needed. To ensure that these secondary roles supplement the primary role in nuclear weapons, the secondary roles meet the following criteria:

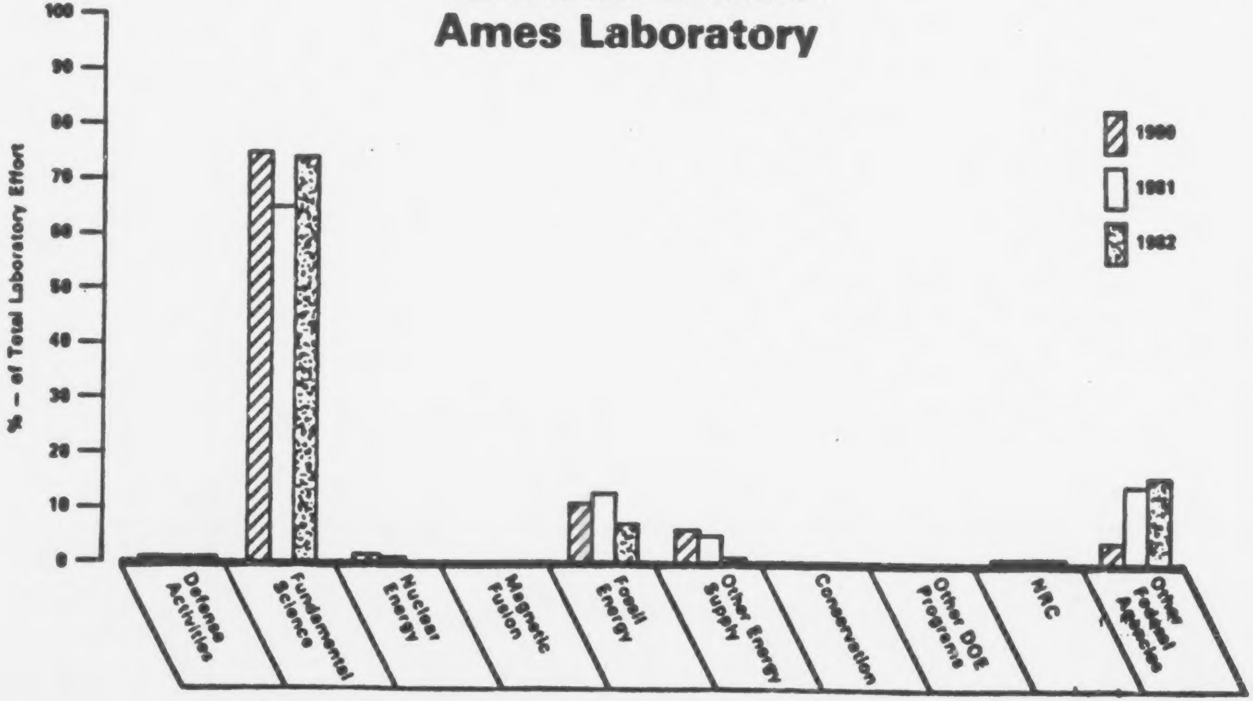
- Maintain (or enhance) capabilities required for the weapons programs.
- Use existing resources.
- Involve the Laboratories in the formulation of both the problem and the approach to attain a solution.
- Avoid "job shop" arrangements while challenging the broad base of Laboratories systems development capability and its total talent.

# APPENDIX II

# Multiprogram Laboratories

## Distribution of Effort

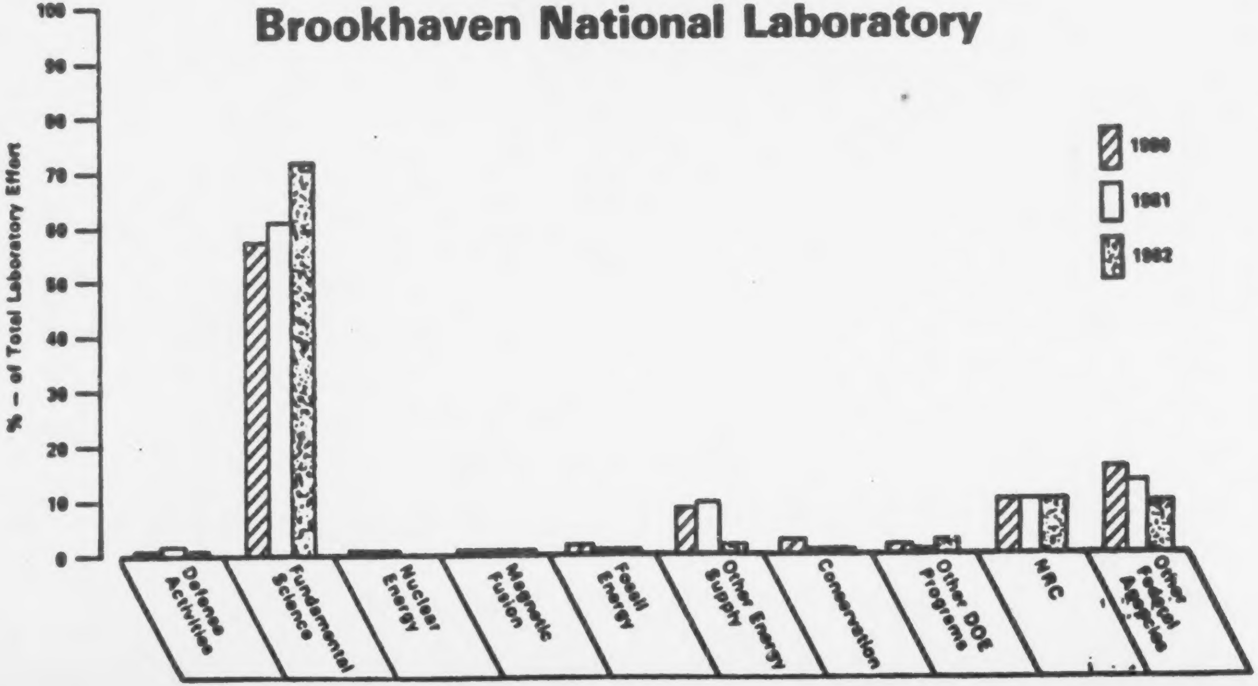
## Ames Laboratory



## Multiprogram Laboratories

### Distribution of Effort

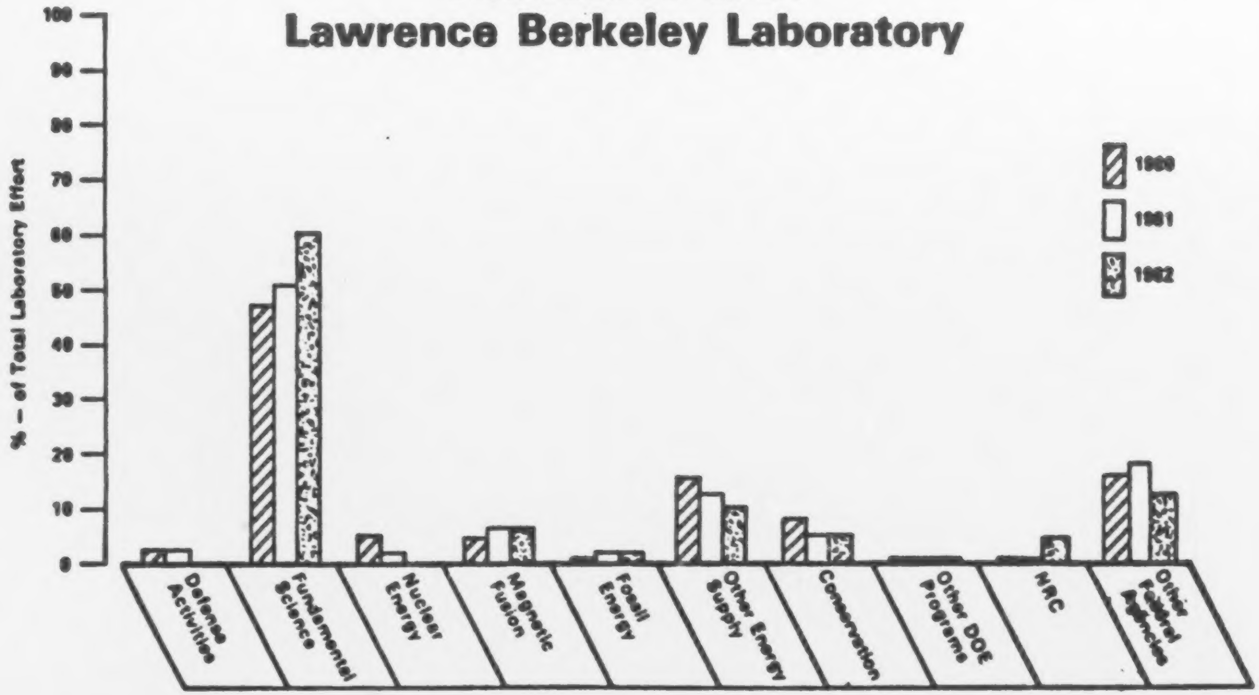
# Brookhaven National Laboratory

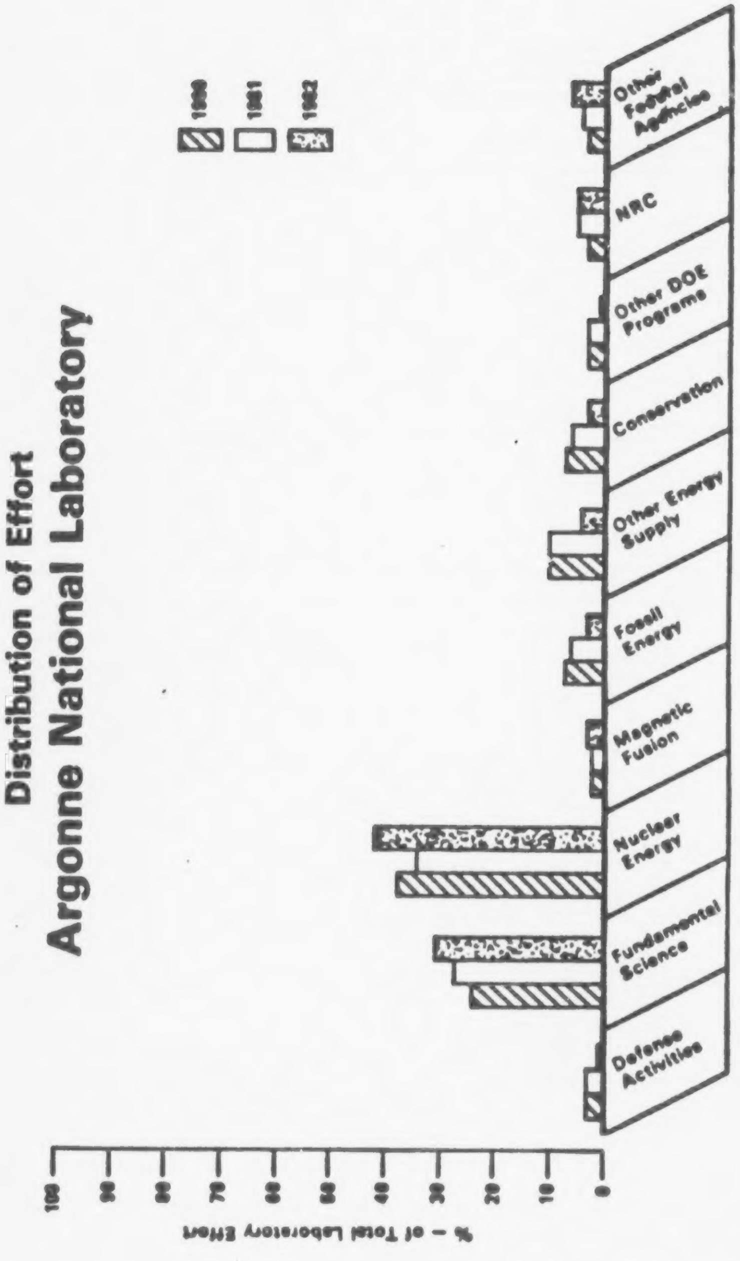


## Multiprogram Laboratories

### Distribution of Effort

## Lawrence Berkeley Laboratory



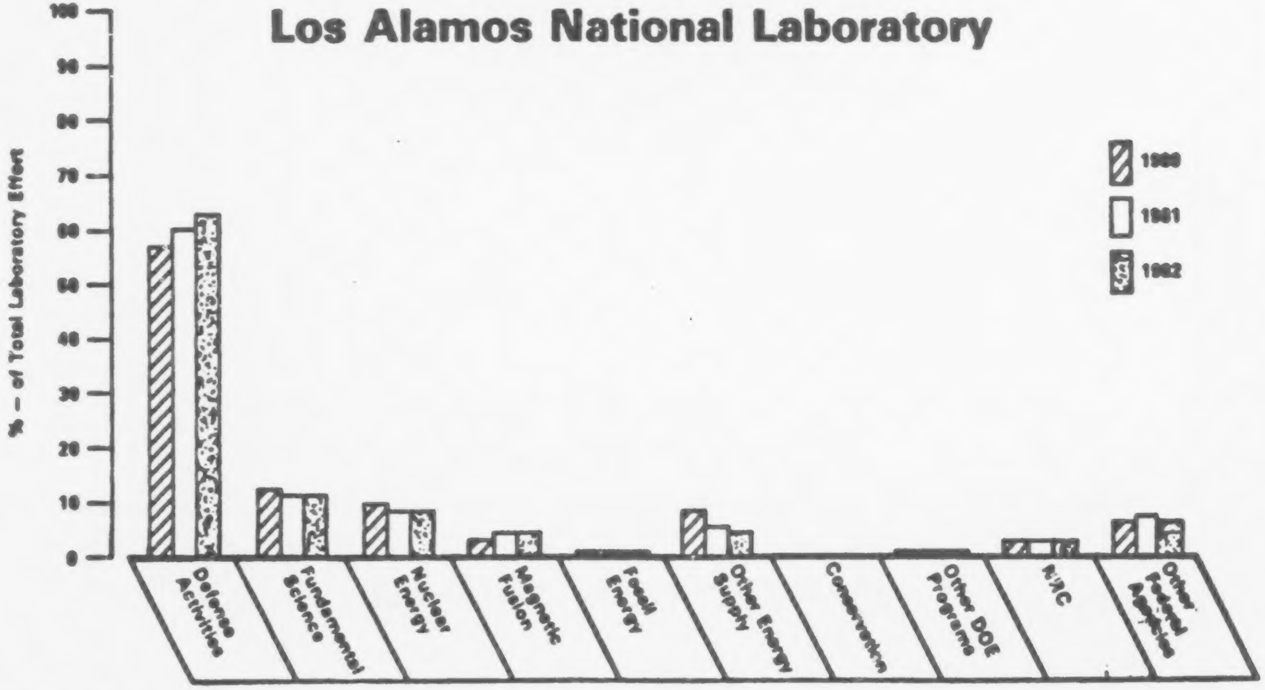


Distribution of Effort
Argonne National Laboratory

# Multiprogram Laboratories

## Distribution of Effort

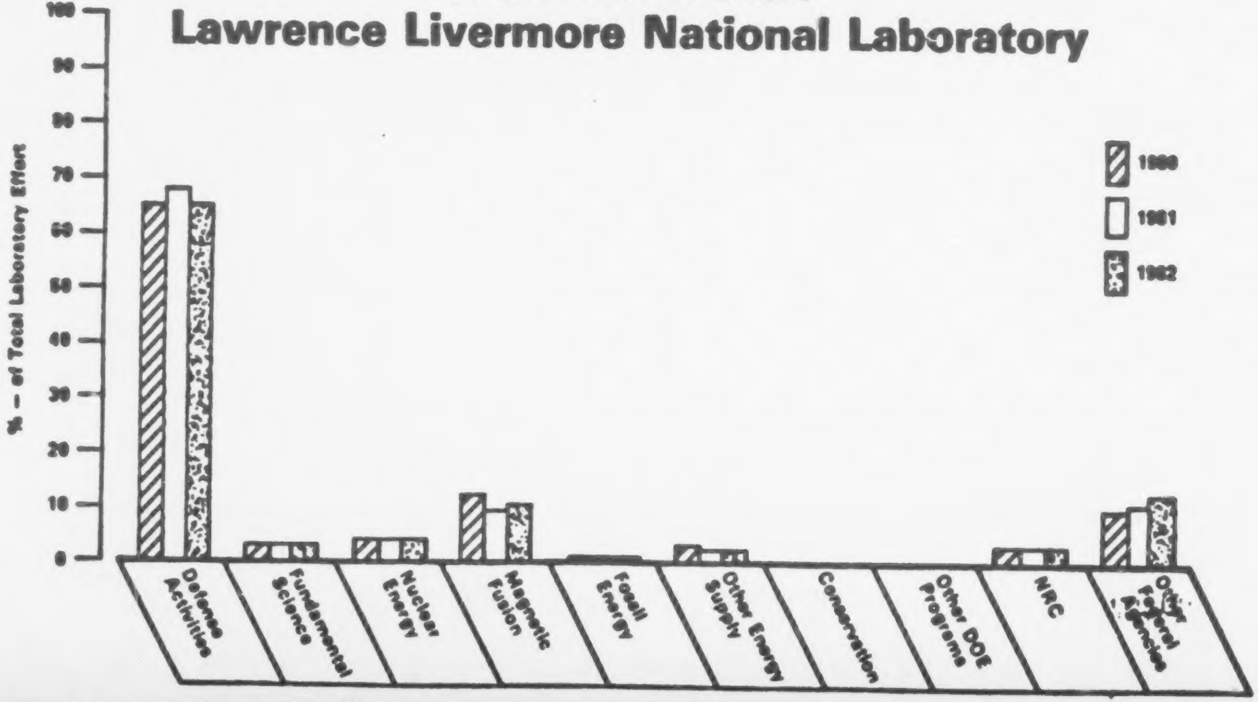
# Los Alamos National Laboratory



## Multiprogram Laboratories

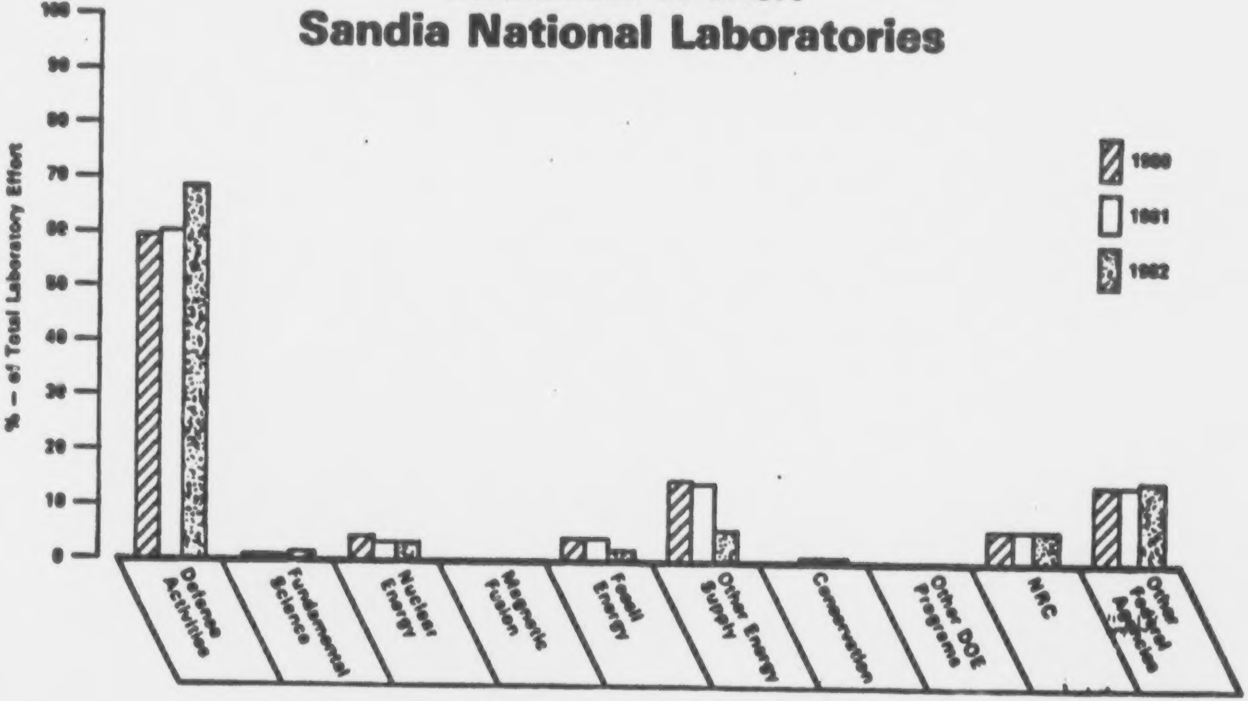
### Distribution of Effort

## Lawrence Livermore National Laboratory



## Multiprogram Laboratories

### Distribution of Effort
## Sandia National Laboratories



# APPENDIX III

Department of Energy
Washington, D.C. 20585

IPI-II-1-82-

JUN 2 9 1982

MEMORANDUM FOR Arthur A. Churm, OPC, CH
Richard E. Constant, OPC, RL
Roger S. Gaither, OPC, LLL
John A. Koch, OPC, NV
Robert M. Poteat, OPC, OR
Howard B. Scheckman, OPC, SAN
Albert Sopp, OPC, AL
Allen F. Westerdahl, OPC, SR
Paul D. Gaetjens, OPC, LANL

SUBJECT: Class Waiver of Government's Rights in Inventions Arising from the Use of DOE Facilities and Facility Contractors by or for Third Party Sponsors, W(A)-82-017

Attached is a copy of a signed Statement of Considerations showing that the above-identified class waiver has been granted. Also attached are model patent and data clauses for agreements with sponsors under the class waiver. As discussed in the Statement of Considerations, the waiver is automatic upon certification of the local DOE Patent Counsel that:

(1) The work to be performed under the use agreement is not covered by another contract or arrangement falling under DOE's statutory patent policy, and is not of sufficient interest to the DOE programmatic mission responsibility to justify DOE supporting the work in whole or in part with direct program funding;

(2) That the sponsor is providing appropriate cost reimbursement for the services performed and/or facilities used as set forth in this class waiver; and

(3) That the terms and conditions for the agreement with the sponsor comply with the waiver and instructions for its implementation as issued by the Assistant General Counsel for Patents.

The attached clauses are approved for use in sponsor agreements under the class waiver, provided, however, that local DOE Patent Counsel shall ascertain whether the clauses should be modified for a particular use-of-facilities arrangement. Where the agreement is between the sponsor and the facility operator, the patent waiver clause may be modified to reflect properly the parties to the agreement. Any other significant changes in the patent waiver clause should not be made without approval of Headquarters.

The data provisions, on the other hand, have been designed to provide DOE's minimum acceptable level of rights in data and data requirements. Local Patent Counsel may modify the data clauses without prior approval to acquire additional rights or data or to fit the particular circumstances of the agreement. For example, where the sponsor's proprietary data are not involved, the provisions for review and removal of data from the facility could be replaced by the sponsor's agreement that none of its proprietary data are at the facility and that DOE shall have unlimited rights in all data at the facility. Local Patent Counsel should work with the facility operator to arrive at contractual arrangements providing the data and rights therein needed by the facility operator. Approval of Headquarters shall be obtained for any confidentiality agreements which do not provide the safeguards of the attached clauses for DOE and the facility operator.

Finally, local Patent Counsel are to coordinate the handling of information and reporting of inventions, as needed, with the facility operator and identify any necessary modifications to the facility operator's contract. Any difficulties in contractual arrangements with facility operators should be reported to this office.

James E. Denny
Assistant General Counsel
for Patents

Attachments

W(A)-82-017

Department of Energy
Washington, D.C. 20585

June 23, 1982

MEMORANDUM FOR R. Tenney Johnson
General Counsel

THRU: Addison G. Wilson
Deputy General Counsel
for Legal Services

SUBJECT: Administrative Order and Class
Waiver for Use of DOE Facilities

Attached for your approval are a Statement of Considerations for a class waiver for use of DOE facilities and an administrative order based on the waiver determination.

The Statement of Considerations has been rewritten to incorporate explicit references to the regulations (41 CFR Part 9-9) under which the waiver is granted and to remove references to patent and data clauses for use under the class waiver.

The use of the administrative order and the rewriting of the Statement of Considerations clarify the fact that making the class waiver available to users of DOE facilities is an implementation of existing regulations and not a new rule.

If you approve the order and Statement of Considerations, please so signify by signing in the spaces provided and return them to me.

James E. Denny
Assistant General Counsel
for Patents

Attachments

## STATEMENT OF CONSIDERATIONS

### Class Waiver of Government Rights in Inventions Arising From The Use of DOE Facilities and Facility Contractors By or For Third Party Sponsors

DOE and its predecessor agencies have long considered its national laboratories and other Government-owned, contractor-operated (GOCO) facilities a unique and valuable national resource that should be made available to the extent feasible for use outside the DOE programmatic mission. In fact, some of DOE's GOCO facilities have as a primary purpose the conduct of basic research, and are available to the public, or to "users," on a regular and routine basis. DOE and its predecessor agencies have developed policies, orders and regulations regarding when, and under what conditions, the DOE GOCO contractors and the facilities they operate can be used for work sponsored by third parties outside of the normal DOE programmatic mission responsibilities, including work sponsored by other federal agencies, state and local governments, foreign governments and international organizations, and foreign and domestic private parties.

It is the purpose of this class waiver to provide a waiver of patent rights under the authority of the Atomic Energy Act of 1954, as amended (42 USC 2182) and section 9 of the Federal Nonnuclear Energy Research and Development Act of 1974 (42 USC 5908) and the regulations of 41 CFR Part 9-9 promulgated thereunder whenever third party sponsors procure R&D and related technical services, or use of facilities, from DOE GOCO facilities and operating contractors on a cost reimbursable basis under any of the established DOE programs for making such services or facilities available. More specifically, this class waiver applies to:

(1) Third party sponsors procuring R&D and related technical services from DOE operating contractors and/or use of DOE GOCO facilities (i.e., work for and/or by others);

(2) Where the work to be performed is not subject to an existing (a) interagency agreement or memorandum of understanding with another federal agency, (b) international agreement with a foreign governmental organization, or (c) a contract, grant, or cooperative agreement with a state or local government, or private foreign or domestic party under DOE's programmatic activities, but is subject to a written agreement with DOE or its operating contractor for work to be performed or facilities to be used under a DOE established or approved program for making such services or facilities available to third party sponsors;

(3) Where the work to be performed by and/or for the sponsor is primarily the interest and work of the sponsor, and is not sufficiently within DOE's programmatic mission responsibilities to cause DOE to support the work in whole or in part with direct program funding;

(4) Where the sponsor is providing DOE or the operating contractor cost reimbursement for the services performed and/or facility used. For the purpose of this class waiver, cost reimbursement means (a) full cost recovery as defined in the DOE order, regulation or policy under which the work by or for the sponsor is performed, (b) full recovery by DOE of the direct costs to the Government under the GOCO contract, or (c) any other reasonable and equitable approach to obtaining full recovery of direct Government costs as certified by the Patent Counsel servicing the DOE activity managing the facility contract;

(5) Inventions made in the course of or under work by and/or for the sponsor by either the sponsor or the operating contractor; and

(6) Where the terms and conditions of the written agreement between the sponsor and DOE or its operating contractor are approved by the Assistant General Counsel for Patents.

R&D work performed by DOE operating contractors and/or in DOE GOCO facilities by third party sponsors creates a benefit to DOE, the sponsor and the general public. Normally, programs providing such services and facilities are made available on a basis which is noninterfering with DOE program activities, which is not in competition with private R&D facilities, and which offers the services and facilities to all qualified sponsors equally. While the Government is reimbursed for the costs incurred, the facility and operating contractor are assured of the maintenance of the GOCO's capabilities, are provided the opportunity for stimulation and growth through the challenge of commercially-related R&D activities, and are provided an additional opportunity for transferring Government developed technology to commercial utilization. The sponsor, on the other hand, has the use and application of a unique research capability to its own research problems which would otherwise be unavailable on a reasonable basis, if at all.

The experience of DOE and its predecessor agencies, however, is that past efforts to make GOCO facilities available have not met with widespread success. The reason for this, at least in part, has been the actual or perceived patent and data policies under which the facilities were available. Under AEC policies, the Government took title to inventions, and any technical data generated was made publicly available. Under ERDA and present DOE policies, patent waivers are available on a case-by-case basis and privately developed proprietary data of the sponsor can be protected. Nevertheless, the perception of DOE's policies, the case-by-case nature of their application, and/or the delays incurred in their application have served as a barrier to making DOE's GOCO facilities and R&D capabilities available to private sponsors.

The reluctance of private sponsors to pay the Government to perform R&D services on their behalf without protection of their proprietary commercial rights is understandable, even in view of the fact that the GOCO facilities have unique capabilities and equipment. It is the usual case that the sponsor has invested substantial private capital in its own research efforts prior to contracting with the Government for services. Especially in the case of the utilization of DOE's unique nuclear facilities, the use of these facilities may well be the final testing that "proves out" an invention in which the sponsor has invested substantial resources, and therefore creates a "reduction-to-practice" of the invention under the use agreement. Without a patent waiver, the invention would be owned by the Federal Government. Additionally, in the normal situation, the sponsor will be required to provide the operating contractor with privately developed background and technical data which the sponsor considers to be, and has treated as, proprietary. The results of the work of the operating contractor, or the data produced as a result of utilization of GOCO facilities, will usually contain much of this proprietary information. In addition, these results and data will contain information which the sponsor wishes, and which the private parties normally consider, to be proprietary.

It is believed that a waiver of the class of inventions created by facility contractors and sponsors, to the class of sponsors as defined above, is in the best interests of the United States and the general public, and is justifiable under the objectives to be attained and determinations to be made under DOE's statutory waiver policy. First, such a waiver is necessary in order to obtain a wider utilization by or for third parties of the unique capabilities and facilities of DOE's GOCO contractors. As stated above, utilization of these facilities by and for third party sponsors is not only a benefit to the sponsor, but also to DOE through the maintenance of the operating contractor's capabilities, the experience gained by performing challenging R&D tasks and the retention of competent teams in the facilities for current and future DOE missions. Also, such use better enables the Government to transfer the technology and research capabilities at these facilities to commercial applications. Accordingly the waiver would best address the statutory objectives and considerations regarding participation in DOE's programs and encouraging commercial utilization of the results of DOE's R&D efforts found in Section 9-9.109-6(a) and (b) of 41 CFR Part 9-9.

Secondly, these situations often involve research efforts in which the sponsor has undertaken private research efforts, in which the sponsor has sufficient interest to procure additional research efforts through the use of DOE's operating contractors and/or GOCO facilities, and which presumably the sponsor will continue to support. These activities, by definition, represent research areas where DOE has insufficient programmatic interest to support the research either in whole or in part, and where the facilities involved are available on a noninterfering basis to DOE's own research mission. As a result, the sponsor has the primary equity in these situations. While the Government has some equity under such agreements in view of the fact that its facilities and capabilities, which are unique and not otherwise reasonably available, have been established at the taxpayers' expense, the reservation of the Government's royalty-free license in waived inventions, along with the standard "march-in rights," is believed to be commensurate with this equity. The waiver will also recognize the contribution factors of Section 9-9.109-6(b) in view of the sponsor's past and anticipated future contribution towards commercialization.

The availability of this class waiver shall be automatic, and granted without a request or petition by the sponsor, upon certification by the local DOE Patent Counsel of the DOE activity responsible for the GOCO contractor that:

(1) The work to be performed under the use agreement is not covered by another contract or arrangement falling under DOE's statutory patent policy, and is not of sufficient interest to the DOE programmatic mission responsibility to justify DOE supporting the work in whole or in part with direct program funding;

(2) That the sponsor is providing appropriate cost reimbursement for the services performed and/or facilities used as set forth in this class waiver; and

(3) That the terms and conditions for the agreement with the sponsor comply with this waiver and instructions for its implementation as issued by the Assistant General Counsel for Patents.

Accordingly, in view of the statutory objectives to be attained and the factors to be considered under DOE's statutory waiver policy, all of which have been considered, it is recommended that a waiver of the class of inventions, to the class of sponsors, and under the situations described above will best serve the interests of the United States and the general public. It is therefore recommended that the waiver be granted.

James E. Denny
Assistant General Counsel
for Patents

## Order for the Disposition of Patent Rights Arising from Use of DOE Facilities

Pursuant to the authority provided in section 152 of the Atomic Energy Act of 1954, 42 U.S.C. 2182, and section 9 of the Federal Nonnuclear Energy Research and Development Act of 1974, as amended, 42 U.S.C. 5908 and the implementing regulations promulgated thereunder for waivers of patent rights, 41 CFR Part 9-9, it is in the best interests of the United States and the general public to grant a waiver of patent rights to the class of users who procure research and development or technical services from DOE operating contractors or use DOE Government-owned, contractor-operated facilities. Therefore, it is hereby ordered that a waiver of patent rights shall be available as set forth in the foregoing Statement of Considerations. The Assistant General Counsel for Patents shall be responsible for issuing instructions for implementation of this waiver in accordance with 41 CFR Part 9-9. This waiver shall not affect any waiver previously granted.

CONCURRENCE:

AW Trivelpiece

Alvin W. Trivelpiece, Director
Office of Energy Research

Date: 6/10/82

APPROVAL:

R. Tenney Johnston

R. Tenney Johnston
General Counsel

Date: June 23, 1982

## ATTACHMENT

### 1. Patent Rights - Use of Facilities (Class Waiver)

(a) Definitions

(1) "Sponsor" means the person or entity with which this agreement is made.

(2) "Subject Invention" means any invention or discovery of the Facility operator or, to the extent the Sponsor is performing any work under this agreement, of the Sponsor, conceived or first actually reduced to practice in the course of or under this agreement, and includes any art, method, process, machine, manufacture, design, or composition of matter, or any new and useful improvement thereof, or any variety of plants, whether patented or unpatented under the Patent Laws of the United States of America or any foreign country.

(3) "States and domestic municipal governments" means the States of the United States, the District of Columbia, Puerto Rico, the Virgin Islands, American Samoa, Guam, the Trust Territory of the Pacific Islands, and any political subdivision and agencies thereof.

(4) "Government agency" includes an executive department, independent commission, board, office, agency, administration, authority, Government corporation, or other Government establishment of the Executive Branch of the Government of the United States of America.

(5) "Facility Operator" means the operating contractor which manages and operates the Government-owned, contractor-operated facility where the work under this agreement is to be performed.

(6) "Patent Counsel" means the DOE Patent Counsel assisting the procuring activity.

(b) Rights of the Sponsor.

(1) Election to retain rights.

Subject to the provisions of paragraph (c)(2) of this clause with respect to any Subject Invention reported and elected in accordance with paragraph (d) of this clause, the Sponsor may elect to obtain the entire right, title and interest in any patent application filed in any country on a Subject Invention and in any resulting patent secured by the Sponsor. Where appropriate, the filing of patent applications by the Sponsor is subject to DOE security regulations and requirements.

(2) Minimum license.

The Sponsor reserves an irrevocable, nonexclusive, paid-up license in each patent application filed in any country on a Subject Invention and any resulting patent in which the Sponsor does not elect to retain title or in which the Government acquires title. The license shall extend to the Sponsor's domestic subsidiaries and affiliates, if any, within the corporate structure of which the Sponsor is a part and shall include the right to grant sublicenses of the same scope to the extent the Sponsor was legally obligated to do so at the time this agreement was entered into. The license shall be transferable only with approval of DOE except when transferred to the successor of that part of the Sponsor's business to which the invention pertains.

(c) Rights of Government.

(1) Assignment to the Government.

The Sponsor agrees to assign to the Government, upon request, the entire right, title, and interest in any country to each Subject Invention of the Sponsor and to each Subject Invention of the Facility Operator to which the Sponsor has acquired title, except to the extent that rights are retained by the Sponsor under paragraph (b)(2) of this clause, where the Sponsor:

(i) Does not elect pursuant to this clause to retain such rights; or

(ii) Fails to have a patent application filed in that country on the Subject Invention or decides not to continue prosecution or not to pay any maintenance fees covering the invention; or

(iii) At any time, the Sponsor no longer desires to retain title.

(2) Terms and Conditions of Waived Rights.

(i) To preserve the Government's residual rights to Subject Inventions, the Sponsor shall take all actions in reporting, electing, filing on, prosecuting and maintaining invention rights promptly, but in any event, in sufficient time to satisfy domestic and foreign statutory and regulatory time requirements, or, if the Sponsor decides not to take appropriate steps to protect the invention rights, it shall notify DOE in sufficient time to permit the Government to file, prosecute and maintain patent applications and any resulting patents prior to the end of such domestic or foreign statutory or regulatory time requirements.

(ii) The Sponsor shall convey or assure the conveyance of any executed instruments necessary to vest in the Government the rights set forth in this clause.

(iii) The Sponsor hereby grants to the Government a nonexclusive, nontransferable paid-up license to make, use, and sell each Subject Invention throughout the world by or on behalf of the Government of the United States (including any Government-agency) and States and domestic municipal governments.

(iv) The Sponsor shall provide the Government a copy of any application filed on a Subject Invention promptly after such application is filed, including its serial number and filing date.

(v) The Sponsor agrees to grant to responsible applicants, upon request of the Government, a license to waived inventions on terms that are reasonable under the circumstances:

(A) Unless the Sponsor, its licensee, or its assignee demonstrates to the Government that effective steps have been taken within three years after a patent issues on such invention to bring the invention to the point of practical application, or that the invention has been made available for licensing royalty-free or on terms that are reasonable in the circumstances, or can show cause why the principal or exclusive rights should be retained for a further period of time; or

(B) To the extent that the invention is required for public use by governmental regulations or as may be necessary to fulfill public health, safety or welfare needs, or for other public purposes stipulated in this contract.

(vi) The Sponsor shall submit written reports at reasonable intervals upon request of the Government during the term of the patent on the Subject invention regarding:

(A) The commercial use that is being made or is intended to be made of the invention; and

(B) The steps taken by the Sponsor or its transferee to bring the invention to the point of practical application or to make the invention available for licensing.

(vii) The Sponsor agrees to refund any amounts received as royalty charges on any Subject Invention in procurements for or on behalf of the Government and to provide for that refund in any instrument transferring rights to any party in the invention.

(d) Invention identification, disclosures, and reports.

(1) The Sponsor shall furnish the Patent Counsel a written report containing full and complete technical information concerning each Subject Invention of the Sponsor within 6 months after conception or first actual reduction to practice, whichever occurs first, in the course of or under this contract, but in any event prior to any on sale, public use or public disclosure of such invention known to the Sponsor. The report shall identify the contract and inventor and shall be sufficiently complete in technical detail and appropriately illustrated by sketch or diagram to convey to one skilled in the art to which the invention pertains a clear understanding of the nature, purpose, operation, and to the extent known, the physical, chemical, biological, or electrical characteristics of the invention. The report should also include any election of patent rights under this clause. When an invention is reported under this paragraph (d), it shall be presumed to have been made in the manner specified in Section (a)(1) and (2) of 42 USC 5908.

(2) The Facility Operator's contract with DOE requires that Subject Inventions of the Facility Operator will be reported to DOE. In addition, DOE shall direct the facility operator to disclose to the Sponsor any such inventions promptly upon conception or first actual reduction to practice, and the Sponsor shall notify DOE promptly thereafter of any election of patent rights under this clause.

(e) Limitation of rights.

Nothing contained in this patent rights clause shall be deemed to give the Government any rights with respect to any invention other than a Subject Invention except as set forth in the Facilities License of paragraph (f).

(f) Facilities License.

In addition to the rights of the parties with respect to inventions or discoveries conceived or first actually reduced to practice in the course of or under this contract, the Sponsor agrees to and does hereby grant to the Government an irrevocable, nonexclusive paid-up license in and to any inventions or discoveries regardless of when conceived or actually reduced to practice or acquired by the Sponsor, which at any time through completion of this contract are owned or controlled by the Sponsor and are incorporated in the facility as a result of this agreement to such an extent that the facility is not restored to the condition existing prior to the agreement (1) to practice or to have practiced by or for the Government at the facility, and (2) to transfer such license with the transfer of that facility. The acceptance or exercise by the Government of the aforesaid rights and license shall not prevent the Government at anytime from contesting the enforceability, validity or scope of, or title to, any rights or patents herein licensed.

## 2. Patent Indemnity-Limited

The Sponsor shall indemnify the Government and the Facility Operator and their officers, agents, and employees against liability, including costs, for infringement of any United States patent arising out of any acts required or directed by the Sponsor to be performed under the agreement to the extent such acts are not normally performed at the facility. Further, the foregoing indemnity shall not apply unless the Sponsor shall have been informed in a reasonable time by the Facility Operator or Government of the suit or action alleging such infringement, and such indemnity shall not apply to a claimed infringement which is settled without the consent of the Sponsor unless required by a court of competent jurisdiction.

## 3. Rights in Technical Data - Use of Facility

(a) Definitions

(1) "Technical Data" means recorded information, regardless of form or characteristic, of a scientific or technical nature. It may, for example, document research, experimental, developmental, demonstration, or engineering work to be usable or used to define a design or process or to procure, produce, support, maintain, or operate material. The data may be graphic or pictorial delineations in media such as drawings or photographs, text in

specifications or related performance or design type documents, or computer software (including computer programs, computer software data bases, and computer software documentation). Examples of technical data include research and engineering data, engineering drawings and associated lists, specifications, standards, process sheets, manuals, technical reports, catalog item identification and related information. Technical data as used in this subpart does not include financial reports, cost analyses, and other information incidental to contract administration.

(2) "Proprietary Data" means technical data which embody trade secrets developed at private expense, such as design procedures or techniques, chemical composition of materials, or manufacturing methods, processes, or treatments, including minor modifications thereof, provided that such data:

(i) Are not generally known or available from other sources without obligation concerning their confidentiality,

(ii) Have not been made available by the owner to others without obligation concerning their confidentiality, and

(iii) Are not already available to the Government without obligation concerning their confidentiality.

(3) "Unlimited Rights" means rights to use, duplicate or disclose technical data, in whole or in part, in any manner and for any purpose whatsoever, and to permit others to do so.

(b) The Sponsor agrees to furnish to DOE or the Facility Operator those data, if any, which are (1) essential to the performance of work by DOE or Facility Operator personnel or (2) necessary for the health and safety of such personnel in the performance of the work. Any data furnished to DOE or the Facility Operator shall be deemed to have been delivered with unlimited rights unless marked as "proprietary data" of the Sponsor.

(c) All technical data produced in the performance of work under this agreement by DOE or the Facility Operator shall, prior to any dissemination, publication, or further disclosure of the data by or on behalf of DOE, be made available to the Sponsor for review and appropriate marking where such data disclose the Sponsor's proprietary data.

(d) The Sponsor agrees that it shall have the sole responsibility for identifying and marking all documents containing proprietary data which are furnished by the Sponsor or produced under this agreement. The Sponsor further agrees to mark each such document by or before termination of the agreement by placing on the cover page thereof a legend identifying the document as proprietary data of the Sponsor and identifying each page and portion thereof to which the marking applies. The Government shall not disclose properly marked proprietary data of the Sponsor outside the Government and the Facility Operator. The Government reserves the right to challenge the proprietary nature of any markings on data.

(e) The Sponsor is solely responsible for the removal of all of its proprietary data from the facility by or before termination of this agreement. The Government shall have unlimited rights in any technical data (including proprietary data) which are not removed from the facility by or before termination of the agreement. The Government shall have unlimited rights in any technical data (including proprietary data) which are incorporated into the facility or equipment under the agreement to such extent that the facility or equipment is not restored to the condition existing prior to such incorporation. Additionally, the Government shall have the unlimited right to perform similar or identical services for other sponsors as long as the Sponsors' furnished proprietary data are not utilized.

(f) The Sponsor agrees to deliver to DOE a nonproprietary description of the work performed under the agreement.

# APPENDIX IV

**U.S. Department of Energy**
**Washington, D.C.**

**ORDER**

DOE 4300.2

10-8-81

SUBJECT: RESEARCH AND DEVELOPMENT WORK PERFORMED FOR OTHERS BY GOVERNMENT-OWNED, CONTRACTOR-OPERATED FACILITIES

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1. PURPOSE. To establish the Department of Energy (DOE) policy, responsibilities, and general administrative procedures for reviewing and approving requests for research and development (R&D) and related technical services from non-DOE sponsors.

2. SCOPE. The provisions of this Order apply to all elements of the Department of Energy and all Government-owned, contractor-operated (GOCO) installations that perform research and development for DOE on a regular basis.

3. REFERENCES.

   a. DOE 5000.1, INSTITUTIONAL PLANNING PROCESS, of 6-25-80, which establishes the Institutional Planning Process.

   b. DOE 5600.1, MANAGEMENT OF THE DEPARTMENT OF ENERGY WEAPON PROGRAM AND WEAPON COMPLEX, of 6-27-79, which establishes the policy and procedures for the management of the DOE weapon program and weapon complex and the utilization of the weapon complex facilities for non-weapon DOE activities.

   c. DOE 5031.1, ADMINISTRATION OF POLICY COORDINATION INSTRUMENTS WITH GOVERNMENT AGENCIES, of 6-19-78, which explains the use of policy coordination instruments.

4. AUTHORITIES. Legislative authority allowing DOE to perform R&D work for others is given in one or more of the following:

   a. Atomic Energy Act of 1954, as amended, sections 31, 32 and 33, which permits the use of DOE's facilities and operating personnel for energy research and development work by domestic and foreign persons, provided that the use will not unduly interfere with DOE work, that adequate commercial facilities are not reasonably available, and that it is specifically authorized in section 31.

   b. Economy Act of June 1932, section 686, which authorizes agencies to place orders with other Government agencies when the head of the ordering agency determines that it is in the interest of the Government to do so.

   c. Office of Management and Budget Circular A-97 which contains rules and regulations permitting Federal agencies to provide specialized or technical services to State and local units of Government under Title III of the Intergovernmental Cooperation Act of 1968.

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INITIATED BY:
Director of Energy Research

d. Department of Energy Organization Act of 8-4-77, section 649(b), which authorizes DOE "to permit the use by public and private agencies, corporations, associations, or other organizations or by individuals of any real property, or any facility, structure, or other improvement thereon, under the custody of the Secretary for Department purposes."

5. DEFINITIONS.

a. Others include all non-DOE sponsors, including other Federal agencies, State, regional and local governments, private individuals, commercial firms, not-for-profit organizations, international bodies, and foreign governments, that request work to be performed for them. Others do not include other DOE GOCO installations.

b. Facilities are any DOE-owned or -leased buildings, land or equipment at DOE's GOCO installations covered by this Order.

c. Research and Development Work for Others is the utilization or employment of the facilities and operating personnel at the DOE GOCO installations specified by this Order in the performance of research and development work requested by others. Such work may include, when appropriate, technical or analytical services. In general, R&D work for others excludes work where DOE has sufficient interest in the work to support it in whole and in part with DOE funding (includes waiving all or part of the costs because of DOE programmatic interest). It does not include:

(1) Services provided at scheduled rates under established Departmental programs, such as routine irradiation services or products, the sale of radioisotopes and heavy water, production and transmission of electricity, and uranium enrichment services.

(2) Work by others, whether or not it is conducted under a Departmental program (e.g., a national user facility such as the Combustion Research Center).

(3) Consulting services by individuals, DOE contractor employees or, foreign visits or assignments or, work or services performed by one DOE GOCO installation for another.

d. Cognizant Secretarial Officer is the officer responsible for the institutional overview of a DOE GOCO installation. These include the Director of Energy Research, the Assistant Secretaries for Nuclear Energy; Environmental Protection, Safety, and Emergency Preparedness; Defense Programs; and Conservation and Renewable Energy.

e. Cognizant Contracting Officer is the Departmental official with immediate and direct responsibility for administering the contract for a GOCO installation (i.e., who obligates Departmental funds and enters into or modifies contracts). This person is usually an operations office manager or his or her designee.

6. POLICY. It is DOE policy that:

   a. Facilities and the operating contractor personnel at DOE's GOCO installations may be used to perform research and development work for others when consistent with authorities or purposes granted DOE by authorizing legislation and other Federal statutes, laws and regulations. In general, such work can only be undertaken if it is determined, on an individual project basis, that:

      (1) The capability to perform the work in domestic private facilities and laboratories is not available on an independent, convenient and timely basis and at a reasonable charge;

      (2) The work will not commit DOE facilities and personnel to the detriment of DOE's program activities; and

      (3) Work must be for purposes authorized by law for the Department.

   b. R&D work for others is always performed under a contractual agreement between DOE and the sponsor and in accordance with DOE procurement and financial regulations.

   c. The overall level of effort devoted to research and development work for others at an installation will be limited, as necessary, to assure that the DOE facilities and personnel required for efficient and effective execution of DOE's mission programs are available.

7. OBJECTIVES. The objectives are to:

   a. Provide a means of assisting other Federal agencies and State and local governments in accomplishing their goals that may otherwise be unattainable, while avoiding unnecessary duplication of effort.

   b. Provide access for others, such as small business and education and other nonprofit institutions, to highly specialized and often unique research and development facilities, expertise, and capabilities.

   c. Assure the maintenance of DOE's research and development and related capabilities, and to provide an opportunity for stimulating their growth for both immediate and future applications.

8. RESPONSIBILITIES AND AUTHORITIES.

   a. The Under Secretary establishes Departmental policies on R&D work for others.

b. Director of Energy Research (ER-1).

(1) Develops and recommends changes in R&D work for others policies to the Under Secretary after coordination with cognizant Secretarial Officers and the Assistant Secretary, Management and Administration.

(2) Periodically reviews operating procedures employed by Secretarial Officers and contracting officers for reviewing, approving, and administering R&D work for others to assure consistency with this Order.

(3) Annually advises the Under Secretary on R&D work for others activities as part of the Institutional Planning Process.

(4) Requests information from Secretarial Officers and contracting. officers, as necessary, to adequately advise the Under Secretary on R&D work for others activities.

c. Cognizant Secretarial Officers.

(1) Provide guidance to cognizant contracting officers on allowable overall level of R&D work for others effort at each assigned GOCO installation. Guidance will be provided in accordance with the procedures on page 7, paragraph 9b.

(2) Approve R&D work for others requests only when referred by cognizant contracting officers under the conditions specified on page 9, paragraph 9e.

(3) Refer matters involving legal questions (e.g., real or apparent conflicts of interest, interpretations of Interagency Agreements or Memorandums of Understanding, or other agreements, and patent issues) to the General Counsel for review, determination, or advice.

(4) Provide summary information on R&D work for others activities as requested by ER-1.

(5) Maintain appropriate records.

d. Assistant Secretary for International Affairs (IA-1).

(1) Reviews and concurs in all R&D work for others requests which involve international activities, whether such requests come from individuals, foreign governments, domestic Government agencies, or domestic international organizations.

(2) Recommends policies and procedures or changes in policies and procedures on such requests.

e. Program Officers furnish data, in a timely manner, to requests from contracting officers concerning R&D work for others, specifically:

   (1) On the impact on their current and planned activities at the GOCO.

   (2) On duplication or overlap of effort due to the relatedness of goals and objectives to their program work at the GOCO facility.

f. The Assistant Secretary, Management and Administration.

   (1) Through the Director of Procurement and Assistance Management, develops and publishes policies, procedures, and regulations concerning contracts, agreements, and their terms and conditions to implement this Order.

   (2) Through the Controller;

      (a) Develops and publishes accounting, budgeting, and other policies necessary to implement this Order.

      (b) Prepares financial reports on R&D work for others as may be requested or required by Congress, the Office of Management and Budget, or the General Accounting Office.

      (c) Maintains and provides financial information on R&D work for others activities in accordance with established Departmental accounting policies.

g. General Counsel (GC-1).

   (1) Determines and provides advice to all elements of DOE on conflict of interest questions, including those arising from situations covered by this Order.

   (2) Provides legal advice and representations to DOE regarding questions involving competition or anti-competitive practices.

   (3) Provides advice on patent and technical data clauses of contractual agreements for R&D work for others and approves waivers of patent rights.

h. Cognizant Contracting Officers.

   (1) Develop procedures for the review and approval of work for others requests that are consistent with the policies and provisions of this Order. These procedures must assure adequate documentation of the decisions made regarding requests.

(2) Monitor overall level of R&D work for others effort at each installation to assure consistency with guidance provided by cognizant Secretarial Officers.

(3) Determine whether or not the capability exists to perform the requested work in domestic private facilities and laboratories on an independent, convenient and timely basis and at a reasonable charge under the procedures on page 7, paragraph 9c.

(4) Determine, coordinating, as needed, with program offices under the procedures on page 7, paragraph 9d, whether requested R&D work for others would utilize DOE personnel and facilities essential to the performance of DOE's program work or is so related in goals and objectives to ongoing or planned DOE program work at that installation that duplication of work may occur.

(5) Obtain review and concurrence of IA-1 on all requests, regardless of dollar amount, involving international activities whether such requests come from individuals, foreign governments, domestic Government agencies or domestic or international organizations.

(6) Determine if the work is consistent with authorities or purposes granted DOE by authorizing legislation and other Federal statutes, laws and regulations.

(7) Approve all R&D work for others requests according to the conditions on page 9, paragraph 9e.

(8) For approved R&D work for others requests, assure that appropriate terms and conditions are contained in the contractual instruments under which the work is to be done.

(9) For each GOCO contractor for which he or she has cognizance, periodically review the contractor's system for managing its R&D work for others activities to assure consistency with this Order.

(10) Provides data, as necessary, for the Controller's preparation of financial reports.

(11) Provide information on R&D work for others activities as requested by ER-1.

## 9. PROCEDURES.

### a. Agreements.

(1) All approved R&D work for others projects shall be performed under a contractual agreement and in accordance with DOE procurement and financial regulations. Agreements used for other Federal agencies are usually "Interagency Agreements," while instruments for

non-Federal sponsors are either "sales agreements" or "intergovernmental agreements." Most requests for R&D work for others from other Federal agencies are in accordance with existing interagency agreements.

(2) Other forms of interagency agreements are Military Interdepartmental Procurement Requests (MIPR) from the Department of Defense, Project Authorization Funding Documents from the Air Force Tactical Command, and Procurement Letters from the United States Geological Survey. Specifics concerning these instruments and their terms and conditions, including patent and data clauses, can be obtained from the Procurement Policy Branch of the Procurement and Assistance Management Directorate. Pricing and financing information may be obtained from the Cost Accounting and Pricing Branch of the Controller's office.

(3) Patent and data rights are negotiated for every R&D work for others request unless covered by a previous agreement, such as a Memorandum of Understanding or International Agreement. In certain cases, DOE Patent Counsel will waive, in advance, the Government's rights in inventions conceived or made in the course of or under such work.

b. Guidance on Overall Level of Effort. For installations involved in the Institutional Planning Process (e.g., multiprogram laboratories), guidance on the percentage of the overall level of effort (in terms of full-time equivalents) to be devoted to R&D work for others activities will be provided via that process. For other installations, the cognizant Secretarial Officer and the cognizant contracting officer will develop and document, through their institutional planning processes, the acceptable level of overall effort to be devoted to R&D work for others. Approved planning levels must be provided in writing annually to ER-1.

c. Determination of Unique DOE Capability to Perform R&D Work for Others. The cognizant contracting officer determines whether the capability exists in domestic private facilities and laboratories to perform the requested work on an independent, convenient, and timely basis, and at a reasonable charge. This determination is based on documented information provided by the sponsor of the work and, when requested by cognizant contracting officer, by the GOCO. Additional information should be obtained independently as necessary by the cognizant contracting officer to verify claims of lack of domestic private capability to perform the work on an independent, convenient, and timely basis, and at a reasonable charge. Such determinations need not be done on a project-by-project basis if it has been previously determined that the DOE capability is unique in the United States. This is especially applicable to unique test facilities, such as the Loss-of-Fluid Test Facility.

d. Coordination with Program Offices. When the cognizant contracting officer, in reviewing a R&D work for others request, determines that there is a possibility that DOE resources may be utilized for R&D work for others to the detriment of DOE activities, or that the goals and objectives are so related to DOE program work that duplication of work could occur, he or she must coordinate that request with the affected program office before approving it. The standard procedure for this coordination is:

(1) The cognizant contracting officer will notify the program manager of the issue concerning the R&D work for others request and will seek to resolve it via telephone conversations. If resolved, documentation on the concurrence should be prepared by the cognizant contracting officer for the project file and a copy provided to the program manager.

(2) If the matter cannot be resolved in this manner, then the cognizant contracting officer must submit the request and associated information needed to assess the issue to the program manager along with his or her recommendation. The program manager must concur or nonconcur by telephone (followed by appropriate documentation), within 10 working days from receipt of the package. No response from the program manager will be evidence of his or her concurrence in the R&D work for others request. However, the cognizant contracting officer is obliged to notify the program manager by letter that he or she is "proceeding with the work without the program manager's explicit concurrence according to the authority granted on page 7, paragraph 9d, DOE 4300.2 ."

(3) This procedure may be modified by mutual agreement between the cognizant contracting officer and the program manager to fit their particular needs and requirements. Any changes should be documented in writing and a copy sent to ER-1.

(4) R&D work for others requests involving international activities must be concurred on by IA-1.

e. Approval. Based on the determination and coordination required on page 6, subparagraphs 8h(3) through (6), the cognizant contracting officer has the authority to approve all R&D work for others requests except those that result in exceeding the overall limit on the R&D work for others effort at the installation, as provided in the procedures. In the latter case the cognizant contracting officer must submit the request to the cognizant Secretarial Officer for approval or disapproval along with a recommendation that either the work be refused or that the limit be temporarily or permanently raised. The cognizant Secretarial Officer may modify this procedure but any modification must be in writing and include a brief justification, and a copy must be sent to ER-1.

William S. Heffelfinger
Assistant Secretary
Management and Administration

# APPENDIX V

**U.S. Department of Energy**
**Washington, D.C.**

**ORDER**

DOE 5000.1

6-25-80

SUBJECT: INSTITUTIONAL PLANNING PROCESS

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1. PURPOSE. This Order establishes the Institutional Planning Process for the Department of Energy (DOE) multiprogram laboratories. The process is the principal means by which the cognizant Departmental officers fulfill their responsibilities in regard to the multiprogram laboratories assigned to them, and by which all Departmental officers ensure their needs for utilization of multiprogram laboratories are appropriately considered and accommodated. It is the process of managing the placement of work at the laboratories and for conducting institutional long-range planning for the laboratories. It is the process for assuring that plans of the laboratories are consistent with Departmental policy and programs.

2. SCOPE. The provisions of this Order apply to all elements of the Department of Energy (DOE) which utilize the multiprogram laboratories.

3. BACKGROUND. The Institutional Planning Process for the Government-owned and contractor-operated multiprogram laboratories and the Solar Energy Research Institute is conducted by the cognizant Departmental officer to whom they are assigned:

   a. Assistant Secretary for Conservation and Solar Energy: Solar Energy Research Institute

   b. Assistant Secretary for Defense Programs:

      (1) Lawrence Livermore National Laboratory

      (2) Los Alamos National Scientific Laboratory

      (3) Sandia National Laboratories

      (4) Savannah River Laboratory

   c. Director of Energy Research:

      (1) Ames Laboratory

      (2) Argonne National Laboratory

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INITIATED BY:
Office of Energy Research

(3) Brookhaven National Laboratory

(4) Lawrence Berkeley Laboratory

(5) Oak Ridge National Laboratory

d. Assistant Secretary for Nuclear Energy:

(1) Hanford Engineering Development Laboratory

(2) Idaho National Engineering Laboratory

(3) Pacific Northwest Laboratory

4. REFERENCES.

a. DOE 1130.1, "Field and Laboratory Coordination Council," of 8-22-78, which established the Field and Laboratory Coordination Council.

b. DOE 5600.1, "Management of the Department of Energy Weapon Program and Weapon Complex," of 6-27-79, which established the policy and procedures for the management of the Department of Energy weapon program and weapon complex and the utilization of the weapon complex facilities for nonweapon DOE activities.

5. POLICY.

a. It is Departmental policy that each cognizant Departmental officer, in managing his or her assigned laboratories, shall use a long-range planning process through which the cognizant Departmental officer, the Departmental officers sponsoring work, the responsible operations office, and the laboratories, reach agreement on the general types and levels of activity which will be conducted at each laboratory through the planning period. This agreement will be documented in a 5-year Institutional Plan for each laboratory, updated annually, and approved by the cognizant Departmental officer. The approved Institutional Plan provides guidance to the laboratory for long-range planning and budget preparation, for site development plans, and is the baseline for placement of work at the laboratories. Work assigned to a laboratory should be within the agreed-to limits, documented in the approved Institutional Plan, or handled as an exception under new work approval procedures which require the approval of the cognizant Departmental officer. Cognizant Departmental officers may delegate approval authority to operations offices.

b. The Director of Energy Research will issue general schedule and format guidance annually, and will coordinate the Departmental Institutional

Planning Process. The cognizant Departmental officers will present the approved Institutional Plans to the Under Secretary annually at a meeting of the Field and Laboratory Coordination Council.

c. Work is appropriate for assignment at the multiprogram laboratories (vis-a-vis university or industry sectors) when it requires use of skills or facilities uniquely available at the laboratories, or is determined not to be within the capability and interest of university or industry to perform, or requires a fast startup or multidisciplinary approach not readily available to the private sector to meet an urgent national research and development need.

d. The laboratories may be assigned lead missions for day-to-day project management or program implementation of important areas of work. Lead mission assignments are initiated and established normally within the Institutional Planning Process. Such assignments are made by outlay program Departmental officers with the concurrence of the assignee laboratory, the appropriate operations office, and the cognizant Departmental officer.

e. The annual replanning process will consist of a call from the Under Secretary; issuance of general schedule and format by the Director of Energy Research; initial guidance and a call to laboratories for preliminary data by cognizant Departmental officers; outlay program Departmental officers' review of preliminary data; onsite review at the laboratories by cognizant Departmental officers; specific guidance and a call for a draft plan by cognizant Departmental officers; outlay Program Departmental officers' review of the draft plans and recommendations to cognizant Departmental officers; approval of plans by cognizant Departmental officers; and, presentation of approved plans to the Under Secretary. Operations offices shall monitor assignment of work to the laboratories throughout the year, and conduct the new work approval procedures, as necessary.

6. RESPONSIBILITIES AND AUTHORITIES.

a. The Under Secretary establishes Departmental policy and overall guidance for utilization of the multiprogram laboratories. In so doing, the Under Secretary uses the Field and Laboratory Coordination Council as an advisory body and as a forum to consider problems raised by any Departmental officer associated with the process. The Under Secretary will resolve any issues raised by outlay program Departmental officers with regard to access to any of the laboratories and will establish Departmental priorities on their use.

b. Director of Energy Research.

(1) Provides staff recommendations to the Under Secretary regarding policy for utilization of the multiprogram laboratories; develops the Departmental Institutional Planning Process; coordinates the annual Institutional Planning Process; coordinates the presentation of the approved Institutional Plans by the cognizant Departmental officers on an annual basis to the Under Secretary; and issues a general schedule and format guidance to the cognizant Departmental officers each year.

(2) The Laboratory Management Division, Office of Field Operations Management, ER-42, is the focal point for this activity and will chair and utilize an Institutional Planning working group composed of Headquarters and field representatives to coordinate the process design and annual implementation. The working group will include, as a minimum, the senior institutional planners of each of the cognizant Departmental officers, and the senior institutional planner of representative laboratories and Operations Offices.

c. Cognizant Departmental Officers.

(1) Utilize the Institutional Planning Process and the general schedule and format in their detailed application of institutional management to the laboratories for which they are responsible.

(2) Provide overall institutional guidance; coordinate program guidance and the assignment of work; establish agreements with outlay program Departmental officers on levels and types of activity; approve lead mission assignments; develop and implement any required detailed procedures; approve Institutional Plans; provide guidelines to the responsible operations office for the implementation of new work approval procedures; and, conduct the process itself including onsite reviews and periodic meetings with the laboratories.

d. Assistant Secretary for Defense Programs.

(1) Manages assigned laboratories in accordance with DOE 5600.1, "Management of the Department of Energy Weapon Program and Weapon Complex."

(2) Modifies the laboratory planning system specified in DOE 5600.1 so that it complies, as much as possible, with all basic requirements of the process, procedures, format, guidance, and schedule established under this Order.

e. Departmental Officers. Utilize the appropriate portions of the Institutional Planning Process and cooperate fully with the cognizant Departmental officers in implementing this process and reaching agreement on work to be placed at the multiprogram laboratories. The decision to conduct work at a laboratory should be based upon the unique skills or facilities at the laboratory and the work should not be in competition with either the university or industry sectors. Work assigned to a laboratory should be within the agreed to limits documented in the Insitutional Plans or handled in accordance with the new work approval procedures.

f. Managers of Operations Offices.

(1) To the extent delegated by, and within the guidelines provided by the cognizant Departmental officers, act as their agents in the execution of the Institutional Plans. Operations offices are responsible for monitoring the allocation of resources to the laboratories through the financial plan process vis-a-vis the Institutional Plan baseline throughout the year. They are also responsible for reviewing new or expanded work requested outside the baseline (recommending approval or rejection to the cognizant Departmental officer); reviewing proposed lead mission assignments; and providing support to the cognizant Departmental officers in the annual development of the Institutional Plans, especially in the areas of general purpose facilities and work for others.

(2) Ensure that the Directors of the multiprogram laboratories for which they are responsible comply with the Institutional Planning requirements established by the respective cognizant Departmental officers and the Departmentwide process.

John C. Sawhill
Deputy Secretary

GPO 870 181

# APPENDIX VI

Tab A

# DETAILED PROCEDURE FOR REVIEWING AND APPROVING NEW AND EXPANDED WORK ASSIGNMENTS

To further the uniform and effective implementation of the New Work Assignment Procedure, as given in the memorandum issued February 21, 1978, by the Under Secretary, the following steps will be followed:

1. At a minimum, the laboratories[1/] transmit concurrently to their responsible Operations Office all laboratory work proposals, including drafts (e.g., 189's), that they send to Headquarters. Additionally, Operations Offices, at their discretion, may request that all laboratory work proposals, or proposals in selected program areas, be transmitted to Headquarters via the Operations Office. Further, laboratories should involve the Operations Office in preliminary, formative discussions related to new or expanded work.

2. Operations Offices commence an immediate screening and review of such work proposals originating from their laboratories with the purpose of determining those that involve new work and expansion of existing work, and assess impacts resulting from the funding of such proposals. A list of possible factors that Operations Offices should employ in their review is given in the

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[1/] The 12 laboratories involved are: ANL, BNL, LBL, LLL, LASL, ORNL, PNL, Sandia, Ames, HEDL, SRL and INEL.

Attachment. The Operations Office will advise the proposed sponsor and the designated Headquarters official (DHO)* of any new or expanded work projects which in the judgment of the Operations Office will have significant policy implications if approved. This advice will be provided to Headquarters in a timely manner, especially in those cases where all proposals are sent to Headquarters through the Operations Office. Significant policy implications must be judged by the Operations Office in concert with direction provided by the DHO*. New or expanded work is that which is previously unanticipated in an approved Institutional Plan. New work involves a new technology, a new field of endeavor, or a different application of an ongoing technology for the particular laboratory. A new budget category may be one indication of this.

In their reviews, Operations Offices will:

a. In lieu of an approved Institutional Plan for 1978, utilize the June 1978 financial plan and the laboratory manpower levels** (approved by the Under Secretary on April 25) and the corresponding approved 189's as a program baseline for their laboratories in determining new work and expanded work.

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* The Assistant Secretary or Director of Energy Research to whom a laboratory is assigned.

** Because there exist some definition and implementation problems with these manpower guidance figures, additional guidance will be provided.

b. Assume the maximum overall staffing growth of laboratories is to be limited to 2% per year over FY 1978 approved manpower levels.

3. Headquarters program offices will incorporate the Operations Offices' comments concerning a laboratory work proposal into their decision process for determining work to be placed in the laboratories. In those cases where new or expanded work proposals are already in Headquarters (and therefore lack Operations Office comments), Headquarters program divisions should notify the Operations Office involved and request their input before the proposed work is approved and funded. In general, it is requested that Headquarters program divisions approve work proposals as early as possible during the fiscal year and that plans to fund work be fully coordinated with Operations Offices on a periodic and consolidated basis. To facilitate communications, both Operations Offices and Headquarters program Assistant Secretaries, Director of Energy Research and Administrators of the Economic Regulatory Administration and the Energy Information Administration are requested to designate a point of contact for such matters. (Depending on the organization, these contacts may be at the program division level.)

4. When an Operations Office receives a program communication funding a work proposal, they will screen it to determine if it involves new work or expanded work. If so, they will review it to determine its impact on the laboratory, employing the factors given in the Attachment and using the analysis resulting from the review of the work proposal when it went to Headquarters (if available).[2/] The Operations Office will notify the Headquarters program division and the DHO responsible for the laboratory of any work that they expect will cause a significant policy impact if approved. Significant policy implication must be judged by the Operations Office in concert with direction provided by the DHO. In cases of significant impact, the Operations Office can expect to be requested to prepare an analysis of the impacts and to provide recommendations. Final acceptance or refusal of new or expanded work involving significant impact on the laboratory will be made by the DHO, except as delegated to the Operations Office by the DHO. It is expected that the Operations Office will participate in (or conduct, if requested) negotiations with sponsors of such work, as necessary, to resolve any concerns that may be raised in the course of these reviews.

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2/ This review will be minimal if the work package was previously reviewed on the way to Headquarters.

5. The above procedures apply to reimbursable work for other Federal agencies, work for others and work proposals submitted in the annual budget process.

Attachment: Factors for Reviewing
New Work Assignments

Attachment

## FACTORS FOR REVIEWING NEW AND EXPANDED WORK ASSIGNMENTS

The following areas, factors and criteria are general guidelines for review and assessment by the Operations Office of laboratory new and expanded work assignments. They represent a general framework of those elements for which Operations Offices review may be particularly valuable and should be emphasized. They do not limit or constrain Operations Office review, assessment or comments in any way:

- o Relationship to approved Institutional Plan (or in FY 1978, to the June Financial Plan and April 25 laboratory manpower levels for all laboratories except LASL, LLL and Sandia).
- o Development of long-term laboratory commitment versus one-time-only assignment.
- o Need for particular laboratory capabilities, especially unique existing R&D facilities or resources not available elsewhere.
- o Requirement for new R&D facilities which could/would not be duplicated elsewhere, thus implying a permanent commitment.
- o Compatibility with and benefit to existing laboratory programs and current manpower skill mix (e.g., readily available staff versus new talent to be recruited).

- Mix of program work to be done in-house and subcontracted and the laboratory's role in managing the subcontracted work.
- Effect on overall management of the organization (i.e., is any effort such that it might require a disproportionate share of management attention?).
- Effect on Operations Office capability to support the work.
- Impact (schedule, quality) on ongoing laboratory DOE programs and associated staffing/facilities.
- Effect on support requirements, both short- and long-term:
  - housing of personnel, particularly office space
  - loading on support facilities and equipment; particularly ADP capabilities
  - GP requirements (GPP, GPF, GPE)
  - loading on support functions, e.g., procurement.
- Degree to which the work is more appropriate for university/commercial sector.
- Relationship to delegated Operations Office program/project responsibilities.
- Relationship to lead mission areas assigned to the laboratory.

2

Department of Energy
Washington, D.C. 20545

FEB 21 1978

MEMORANDUM FOR: Those on Attached List

FROM: Under Secretary,

SUBJECT: PROCEDURE FOR NEW WORK ASSIGNMENTS AT R&D LABORATORIES

## A. Introduction

Effective immediately and pending publication of an IMD, the procedures of this document are to be followed when an Assistant Secretary or other appropriate requesting (Headquarters) official wishes to place previously-unanticipated work at R&D laboratories which are assigned to another Assistant Secretary, the Director of Energy Research or to the Under Secretary. It is expected that work which has been anticipated well in advance will have been included in the Institutional Plans for that laboratory and will be approved through that process. This procedure, then, relates to either a significant commitment to new areas of work not previously identified for the laboratory by Institutional Plans or to a significant expansion of work previously identified.

As used herein, the term "laboratories" refers to the eight "national" laboratories and Ames. In the case of INEL, SRL, HEDL, and the Energy Research Centers, arrangements to assign new work should be made directly with the Assistant Secretary for Energy Technology; in the case of other dedicated laboratories (e.g., Fermi, LMEC, Bates, etc.), arrangements should be made with the pertinent Assistant Secretary or the Director of Energy Research.

As used below, the term responsible Operations Office is the one which has contract administration responsibility for a given laboratory. The term designated Headquarters official refers to the Assistant Secretary, Director of Energy Research or Under Secretary to whom a laboratory is assigned.

The term work package is used to denote the package of work which it is desired to assign to a laboratory; a work package may consist of several specific tasks, where task is the basic unit of the TAPS System (expected to replace the 189 tasking system).

In the sections which follow, the general philosophy is that the contacts with and arrangements for work at a laboratory are to be handled by the responsible Operations Office who acts for the designated Headquarters official to whom the laboratory is assigned. Final approval for placement of work at a laboratory is to be made by the designated Headquarters official, who may delegate this responsibility to the Operations Office.

## B. Familiarization and Pre-Proposal Discussion Phase

In this phase, direct and informal discussions between the requesting Headquarters official and the laboratory which is expected to be the performer of the activity are encouraged and will be arranged through the auspices of or with the knowledge of the responsible Operations Office, which will participate as appropriate.

The requesting official may contact the Secretariat of the Field and Laboratory Coordination Council if he needs information as to which laboratories might have the capabilities he desires.

The responsible Operations Office will inform the requesting official of any restrictions or constraints on the use of a given laboratory.

## C. Work Package Formulation Phase

The requesting official will formulate a work package proposal request describing the nature of the activity which he desires to have the laboratory undertake. The proposal request will go to the Operations Office as well as to the laboratory. The laboratory will prepare a work package proposal which will be forwarded to the requesting official by the Operations Office who will provide supplementary information as necessary. In some instances, laboratories may originate work package proposals without prior formal proposal requests; copies of such proposals will be simultaneously sent to the Operations Office.

The Operations Office, acting for the designated Headquarters official, will determine whether a work package proposal falls within the scope of previous approvals and thresholds (such as to be established by Institutional Plans) or should be handled under this procedure since it represents a significant deviation from the established size and scope of the laboratory activities. The latter determination would be made if the work package proposal represents a major long-term commitment to a new area of work for the laboratory (such as work under a B&R subactivity not previously assigned to that laboratory) or is a major expansion of previously-assigned work.

The Operations Office will keep the designated Headquarters official informed of the status of proposal request and work package proposal activity.

## D. Work Package Placement

When the requesting official decides that there is an acceptable proposal (this may take several formal or informal iterations and exchanges with the laboratory and the Operations Offices), a work authorization order (expected to be TAPS documentation) will be prepared and sent to the Operations Office which will obtain the approval of the designated Headquarters official. After approval, the requesting official will then be advised and the work will be authorized at the laboratory upon receipt of financial plan funding.

Once the work has gotten underway, direct technical discussions may be held between the requesting official and the laboratory, with the Operations Office participating in such interchanges as dictated by the nature of the assignment.

## E. Implementation

Information concerning accepted work authorizations will be supplied by the Operations Office to the Secretariat of the Field and Laboratory Coordination Council which will be able to keep the Council informed of the placement of new work at the laboratories.

In the event of a disagreement among the Operations Office, the laboratory, or the requesting official, the matter will be jointly referred first to the designated Headquarters official and then, if necessary, the Under Secretary.

# APPENDIX VII

**U.S. Department of Energy**
**Washington, D.C.**

# ORDER

DOE 5800.1

3-25-82

SUBJECT: RESEARCH AND DEVELOPMENT LABORATORY TECHNOLOGY TRANSFER PROGRAM

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1. PURPOSE. To establish the policy and responsibilities for the management of the Department of Energy (DOE) Research and Development (R&D) laboratory technology transfer program.

2. SCOPE. The provisions of this Order apply to all elements of the Department which are involved in the administration, management, and support of the DOE laboratories.

3. REFERENCES.

   a. DOE 5000.1, INSTITUTIONAL PLANNING PROCESS, of 6-25-80, which establishes policy and responsibilities for administering the DOE multiprogram laboratories.

   b. DOE 5600.1, MANAGEMENT OF THE DEPARTMENT OF ENERGY WEAPON PROGRAM AND WEAPON COMPLEX, of 6-27-79, which establishes policy and responsibilities for management of the weapon complex and program.

   c. Public Law 96-480, The Stevenson-Wydler Technology Innovation Act of 1980, which requires technology transfer by federally funded R&D laboratories.

4. POLICY AND OBJECTIVES.

   a. Policy. It is DOE policy that technology transfer activities as required by Public Law 96-480 are legitimate functions of the R&D laboratories and will be conducted, as appropriate, at those laboratories specified in this Order.

   b. Objectives.

      (1) To establish a Department policy and R&D laboratory technology transfer program responsive to the requirements of Public Law 96-480.

      (2) To require the conduct, as appropriate, of technology transfer activities at the R&D laboratories.

      (3) To assure the application of consistent assumptions and procedures in the planning and conduct of technology transfer activities at the R&D laboratories.

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Director of Energy Research

(4) To assure appropriate and effective administration and management of the technology transfer program by the cognizant Secretarial Officers assigned responsibility for the R&D laboratories.

(5) To assure the timely and accurate collection of data and information about technology transfer for the purpose of describing the overall DOE effort in the technology transfer program.

5. DEFINITIONS.

a. Technology Transfer. The transformation of R&D into processes, products, and services that can be applied to State and local government and private sector needs. The R&D laboratory technology transfer program emphasizes personal interaction between the technical staff of the R&D laboratories and representatives of the public and private sectors. The R&D laboratory technology transfer program includes the following activities:

(1) Assessment of R&D projects for applicability to the needs of the private sector and State and local governments.

(2) Application and/or adaptation of research or technology into processes, products, and services for use by the private sector and State and local governments.

(3) Technical assistance to the private sector and State and local governments in adapting federally developed technology for use.

(4) Cooperation with technology transfer brokers to move technology from the laboratories to the private sector and State and local governments.

(5) Licensing of DOE-owned patented technology for commercial use.

b. Technology Transfer Brokers. Any institution or organization which provides linkage between the R&D source and the public or private sector utilizing the R&D.

c. Cognizant Secretarial Officers and R&D Laboratories. Attachment 1 identifies the cognizant Secretarial Officers and the DOE R&D laboratories under their purview.

6. RESPONSIBILITIES AND AUTHORITIES.

a. Under Secretary establishes DOE policy and overall guidance for the R&D laboratory technology transfer program. In so doing, the Under Secretary is supported by the Director of Energy Research.

b. Director of Energy Research.

(1) Provides staff recommendations to the Under Secretary regarding policy for the conduct of the technology transfer program by the R&D laboratories.

(2) Provides annual schedule and guidance to cognizant Secretarial Officers for the DOE R&D laboratory technology transfer program. The technology transfer program will include the approval of an annual 5-year technology transfer program plan by the cognizant Secretarial Officers and the submission of an annual technology transfer program report by each laboratory. The development of the guidance will be coordinated with the cognizant Secretarial Officers.

(3) Coordinates the technology transfer program as part of the institutional planning process.

(4) Provides guidance regarding the incorporation of the technology transfer program functions into the existing institutional planning process for multiprogram laboratories. For those R&D laboratories not included in the existing institutional planning process provides guidance regarding utilization of applicable elements of that process so as to avoid creating any new duplicative process or paper requirement.

(5) Coordinates the preparation of an annual technology transfer program report.

(6) Provides an interagency coordination point for technology transfer programs at DOE laboratories as appropriate.

(7) The Laboratory Management Division, Office of Field Operations Management, ER-42, is the focal point for coordinating the technology transfer program and for interagency coordination as appropriate.

c. Cognizant Secretarial Officers.

(1) Assure that the technology transfer program is incorporated into the activities of the R&D laboratories under their responsibility to the extent appropriate and consistent with overall DOE policy.

(2) Coordinate with the Director of Energy Research regarding general policies, assumptions, definitions, and procedures affecting the technology transfer program.

(3) Administer the technology transfer program for the R&D laboratories for which they are responsible.

(4) Incorporate the technology transfer program into the existing institutional planning process for multiprogram laboratories and utilize applicable elements of the institutional planning process for R&D laboratories not now included in that process.

(5) Provide guidance through the appropriate operations office, as applicable, for the R&D laboratories under their responsibility regarding the development and implementation of the technology transfer program consistent with the schedule and guidance issued by the Director of Energy Research.

(6) Approve annual 5-year technology transfer program plan for the R&D laboratories under their responsibility, utilizing the institutional planning process where appropriate.

d. Assistant Secretary, Management and Administration provides support for the technology transfer program at R&D laboratories as appropriate.

e. Assistant Secretary for Defense Programs provides security classification guidance on new areas of information as appropriate.

f. Assistant Secretary for Congressional, Intergovernmental, and Public Affairs provides recommendations to the Under Secretary regarding policy for conduct of and effectiveness of the technology transfer program at the R&D laboratories in regard to State and local governments.

g. Assistant General Counsel for Patents.

(1) Administers patent licensing program of DOE, including granting of licenses to qualified applicants.

(2) Negotiates patent licenses, including charging of royalties where appropriate.

(3) Coordinates with operations offices and R&D laboratories to provide technical assistance to patent licenses when appropriate.

h. Deputy Assistant Secretary for Naval Reactors.

(1) Establishes procedures for all technology transfer concerning Naval reactors information at R&D laboratories.

(2) Approves all technology transfers concerning information in the Naval reactors program.

i. Managers of Operations Offices.

(1) Overview laboratory compliance with the guidance provided by the Director of Energy Research and the cognizant Secretarial Officers concerning the technology transfer program at R&D laboratories under their purview.

(2) Advise and concur in the individual R&D laboratory technology transfer program annual 5-year plans and annual reports.

William S. Heffelfinger
Assistant Secretary
Management and Administration

| R&D LABORATORIES AND RESPONSIBLE COGNIZANT SECRETARIAL OFFICERS [1/]

1. Director of Energy Research.

   a. Ames Laboratory

   b. Argonne National Laboratory

   c. Brookhaven National Laboratory

   d. Lawrence Berkeley Laboratory

   e. Oak Ridge National Laboratory

   f. Fermi National Accelerator Laboratory

   g. Princeton Plasma Physics Laboratory

|  h. Stanford Linear Accelerator Center

   i. Bates Linear Accelerator Facility

   j. Center for Energy and Environment Research

|  k. Environmental Measurements Laboratory [2/]

   l. Inhalation Toxicology Research Laboratory

   m. Laboratory for Energy Related Health Research

|  n. Laboratory of Biomedical and Environmental Sciences

   o. Laboratory of Radiobiology and Environmental Health

|  p. Michigan State University (MSU)-DOE Plant Research Laboratory

   q. Notre Dame Radiation Laboratory

   r. Oak Ridge Associated Universities

   s. Radiobiology Laboratory

   t. Savannah River Ecology Laboratory

   u. University of Rochester Biomedical Laboratory

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[1/] R&D laboratories are contractor-operated except where noted.
[2/] Government-owned, Government-operated laboratory.

Vertical line denotes change.

2. Assistant Secretary for Defense Programs.
    - a. Lawrence Livermore National Laboratory
    - b. Los Alamos National Laboratory
    - c. Sandia National Laboratories
    - d. New Brunswick Laboratory 2/
    - e. Savannah River Laboratory
3. Assistant Secretary for Nuclear Energy.
    - a. Pacific Northwest Laboratory
    - b. Bettis Atomic Power Laboratory
    - c. Hanford Engineering Development Laboratory
    - d. Idaho National Engineering Laboratory
    - e. Knolls Atomic Power Laboratory
    - f. Energy Technology Engineering Center
4. Assistant Secretary for Fossil Energy.
    - a. Bartlesville Energy Technology Center 2/
    - b. Grand Forks Energy Technology Center 2/
    - c. Laramie Energy Technology Center 2/
    - d. Morgantown Energy Technology Center 2/
    - e. Pittsburgh Energy Technology Center 2/
    - f. Carbondale Mining Technology Center 2/
    - g. Pittsburgh Mining Technology Center 2/
5. Assistant Secretary, Conservation and Renewable Energy: Solar Energy Research Institute

2/ Government-owned, Government-operated laboratory.

Vertical line denotes change.

# APPENDIX II

## Additional Statements for the Record

Honorable Don Fuqua
Chairman, House Science and Technology Committee
U.S. House of Representatives
2269 Rayburn House Office Building
Washington, D.C. 20515

Dear Congressman Fuqua:

I am writing to provide the Committee with our comments on the Energy Research Advisory Boards (ERAB) Report on the Department of Energy's multi-program national laboratories. The report was to address the relative roles of national laboratories vis-a-vis industries and universities in meeting the national needs for energy-related research in this country. We understand that your committee will consider this report at a hearing on December 2, 1982.

As a committee of the Association we have been discussing the report at meetings with officials of the Department of Energy and other elements of the Executive and Legislative Branches. Basically, we support the value and need for national laboratories which have specific, focused roles. We believe that the roles of national laboratories have been expanded, over time to include missions that would be more appropriate to universities.

The report does not address the capabilities and missions of universities to conduct innovative, basic research which is essential to their mission. We have asked that the Department of Energy request the ERAB to specifically address university problems in dealing with the Department of Energy, capabilities to help solve energy-related problems and ways in which relationships between national laboratories and universities can be improved. The general consensus is that relationships are poor. We understand that the ERAB has agreed to add these subjects to their review of the roles of multi-purpose laboratories. While the continued review of the question may help solve long-term problems, the immediate basic problem is not addressed.

As pointed out in my letter of August 19, 1982, copy attached, the allocation of public funds for energy research between the national laboratories and the universities is seriously out of balance. Dr. Trivelpiece's reply of October 18, 1982, seems to suggest that there is no problem.

However, we find this view at variance with the research picture displayed in Tables 2.2, 2.20 and 2.21 of the ERAB report. It would appear that dollars allocated to university research are a very small percentage of DOE R&D budgets for FY 1981 and 1982 in particular.

One Dupont Circle, N.W. Washington, D.C. 20036 202 / 293-7120

The Committee's commentary on the ERAB report is enclosed. It is our recommendation that DOE reexamine its R&D allocation in terms of the relative missions of the universities and the national labs. We believe it is imperative to assure continuity and stability of support not only to the development of new basic knowledge but also to the training of the nation's manpower.

Respectfully,

John C. Calhoun (SHS)

John C. Calhoun
Chairman
Committee on Environment
and Energy

R. Clodius
J. Crowley
J. Roschwalb

Enclosures as Stated

ATTACHMENT

Department of Energy
Washington, D.C. 20585

Dr. John C. Calhoun, Jr.
Chairman, Committee on Energy
and the Environment
National Association of State Universities
and Land Grant Colleges
One Dupont Circle, N.W.
Washington, D.C. 20036

Dear Dr. Calhoun:

Thank you for your thoughtful letter of August 19, 1982, regarding the Preliminary Report from the Energy Research Advisory Board (ERAB) on the Multiprogram National Laboratories of the Department of Energy. I have delayed in responding until the final report was completed and released by the Board and I am enclosing a copy for your use. As you will note, this report contains substantially more information than the earlier version and I believe provides a firmer base for discussion.

Your letter raises concerns about the appropriate allocation of support for research to the National Laboratories as contrasted to the university community. Let me state at the outset that we have never viewed the Department's laboratories as "competitors" with the university community for support from the Department. Each "sector" is a major national resource with both differing and complementary missions. For example, the laboratories can never replace, only support, the basic university role in graduate education. Universities, in general, are not able to conceive and implement major multitechnology energy research programs which require large numbers of support personnel and substantial research facilities.

I believe the funding provided by the Department to the National Laboratories and the university community, in general, reflects this proper balance. For example, as indicated in the ERAB final report, the nine Multiprogram National Laboratories received, for in-house research, about 20% in FY 1981 of the Department's non-weapons related R&D budget. This figure excludes both subcontracting and other support provided by the laboratories to university scientists (about $35M in FY 1981) and support for the operation of the considerable user research facilities at the laboratories. These are made available for use by university scientists without cost.

We are proceeding to look in more detail at the non-weapons funding of the laboratories in specific energy R&D areas to make sure that appropriate research programs related to the mission of each laboratory are in place.

As I am sure you are aware, the FY 1983 budget request for the Office of Energy Research also shows a significant increase for university-based research, a trend which has continued since FY 1978.

We will be continuing to look for specific ways in which we can increase the already substantial cooperation and collaboration between university and National Laboratory groups, such as joint research proposals, increasing the availability of laboratory facilities for university use, and providing additional opportunities for graduate student and post-doctoral research. Any suggestions you and your Committee can make to us in this regard will be greatly appreciated, along with your comments on the ERAB final report. I understand that I will be meeting with the Committee at your meeting on October 19 and I will be pleased to discuss these issues with you in more detail at that time.

Sincerely,

Alvin W. Trivelpiece
Director, Office of
Energy Research

Enclosure: Final Report

cc: Dr. Ivan Bennett

National Association
of State Universities
and Land-Grant Colleges

Robert L. Clodius, President

August 19, 1982

Dr. A. W. Trivelpiece
Director, Office of Energy Research
Department of Energy
Washington, D.C.

Dear Dr. Trivelpiece:

I am writing to you as Chairman of the Committee on Energy and the Environment of the National Association of State Universities and Land-Grant Colleges. Our committee has been discussing the "Preliminary Report on the Multiprogram National Laboratories," and I want to convey some of our concerns to you.

We believe that the allocation of public funds for energy research between the national laboratories and the universities is seriously out of balance. And, further, we think that this imbalance (1) decreases the capacity of the university community to meet its unique responsibility for providing the nation's supply of scientific and engineering manpower; (2) increases the probability that important research ideas will not be funded; (3) operates in violation of the principle of equal access to public research monies; (4) tends to decrease the funding of basic research; (5) constitutes a wasteful practice at a time of scarce financial resources; and (6) may bias the allocation of effort among research priorities.

Let me emphasize our strong belief that the Department of Energy's policies on research performance should support a strong component of university research in order to insure an adequate supply of manpower for the nation. The graduate education of scientists and engineers is the special obligation of our universities, and it is in the national interest that they receive adequate public funds for this purpose. This problem can not be alleviated, but rather will be exacerbated, by attempting to bring the laboratories into the mode of graduate education.

It has now become apparent also that researchers in the national laboratories enjoy a competitive advantage in funding over their colleagues in the universities. The existence of these advantages are producing a number of barriers to the free flow of ideas.

These concerns are not addressed in the Preliminary Report. Yet, these are urgent problems in a period of shrinking funds for energy research and in a period of need for greater cooperation between university and government research groups. We

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recognize that it is impractical to alter the Preliminary Report so near to its completion. The purpose of this letter is to tell you about our concerns and to state our intention to pursue these issues further and to bring them to the fore for wider discussion in both government and university circles. Upon the release of the Report, we will review its contents and provide you with our critical comments along the lines indicated above. We trust that such constructive action on our part will prove useful to you and to the Department.

Sincerely,

John C. Calhoun, Jr.
Chairman, Committee on Energy
and the Environment

cc: Dr. George Keyworth
Dr. Ivan Bennett

## Comments on the Report of the Multiprogram Laboratory Panel of the Energy Research Advisory Board

The Final Report of the Multiprogram Laboratory Panel of the Energy Research Advisory Board (ERAB) dated September 1982 has been reviewed by a subcommittee of the Energy and Environment Committee of the National Association of State Universities and Land-Grant Colleges (NASULGC). Those aspects of the final report which deal with the relationship between the multiprogram national laboratories (MPL) and the universities have been reviewed in detail. The comments of the subcommittee are limited to those relationships and the relevant issue of the mission of universities in energy research. This mission has not been recognized in the ERAB report.

The comments of the subcommittee focus on four points. These are: (I) the national trust missions of the multiprogram national laboratories; and the universities; (II) the advantages inherent to the multiprogram national laboratories in competing for the R&D dollars in the DOE budget; (III) the need for base funding of the university mission in energy research; (IV) the need for more effective utilization of the "user facilities" at the national laboratories. In addition, we have provided in Section V, a series of comments and recommendations.

### I. National Trust Missions

The beginning of Chapter IV concerns the roles and missions of the laboratories, industry, and universities relative to overall federal energy research and development policy. The trust mission and core areas for the laboratories are articulated but the trust mission of the universities is not discussed.

The concept that the laboratories are entrusted to provide state-of-the art expertise in areas of energy research and development not possible in industry and universities is generally accepted. For example, the laboratories must maintain critical masses in large multidisciplinary areas; operate large user facilities, etc. Further narrowing to core areas of concentration at the laboratories is recommended. It is important that the core areas at each of the laboratories be defined and that they be supported adequately to maintain their trust.

Universities also have a national R&D trust mission to provide the educated researchers and practitioners for future energy-related research and development. The university role in basic energy research is central not only to discovery of new knowledge but also to educate future researchers. This research education must be mainly in a university setting. Occasional participation in laboratory programs will not satisfy this need. Without new young people educated in energy research and development there will not be critical masses of researchers in the laboratories or industry to enable them to accomplish their missions in the future. Neither the laboratories nor industry can accomplish this education mission.

## II. National Laboratory Competitive Advantage Vis-a-vis Federal R&D Dollars

The DOE laboratories enjoy an institutional advantage in any competition with universities or industry for funding because of built-in disincentives for the DOE Program Managers to "go outside." It is simpler for the Program Managers to deal directly with the laboratories because they can do so on a non-competitive basis, and sometimes at a lower cost to them (depending on who pays for the overhead). Going to universities or industry with grants or contracts requires time-consuming negotiation of agreements and in many cases requires the full panoply of requests for proposals, competitive evaluation and peer review.

The disadvantages also include:

1. zero-base funding for most university research versus incremental annual funding for laboratories;
2. the timing of the "Form 189 process" requires Office Directors to commit funds to laboratories long before they know what their budgets for the coming fiscal year will actually be; universities and industries are left to compete for the scraps;
3. a vastly poorer system of communication and interaction between DOE staff and universities and industries relative to that with the laboratories;
4. in many cases requirements for formal, full-scale proposals from university researchers, in contrast to informal and personal discussion of new research ideas with laboratory researchers.

These disadvantages are institutional and structural, and while steps can and should be taken to alleviate them, it is probably not reasonable to expect that they will be eliminated entirely. Improvement in the relative funding of university-based, energy-related research thus requires a way to avoid these disadvantages. Otherwise, the national laboratories will continue in many cases to siphon off research funds at the expense of university research that is vital to graduate education in energy related fields.

## III. Base Funding for Energy Research at U.S. Universities

Energy R&D programs at U.S. universities are suffering from lack of adequate support which is decimating the ability of the nation's universities to provide the technological base for developing future energy technologies, and to educate adequate numbers of M.S. and Ph.D. students in energy related fields.

Attached are Tables 2.2, 2.20 and 2.21 of Volume II of the ERAB Final Report. Table 2.2 clearly shows that the universities' portion of the DOE budget for R&D is about 10% of that of the total for federally funded research and development centers. Table 2.2 includes both the defense and non-defense portions of the DOE budget for R&D. Tables 2.20 and 2.21 include only the non-defense R&D budgets for DOE for FY 81 and FY 82 respectively. In FY 81 the federally funded research and development centers accounted for 55% and in FY 82 this share was 62%. The university share of the non-defense R&D budgets was 6% in FY 81 and 8% in FY 82. Clearly this reflects a disproportionate distribution when the national trust missions of both the multiprogram national laboratories and the universities are considered.

DOE figures for FY 83 show that less than 5% of the budgets for fossil and solar energy programs will go to universities; for conservation and nuclear programs, the figure is less than 1%. Even in DOE's office of basic energy research, only about 15% of the funds go to universities.

Regardless of how one interprets the above figures in the tables, it is clear that the R&D funds for universities coming from DOE have been relatively constant over the 1979-1982 period and have in fact decreased on a constant dollar basis. This trend at universities is inconsistent with an increasing emphasis on long lead time, high risk, basic research that is now being advocated by the Administration. This subcommittee endorses fully this emphasis as being appropriate to the national needs. However, the participation of the universities in the national energy research program should be increased in a manner consistent with this changing emphasis.

We propose that DOE should review its R&D allocations in terms of the relative mission of the universities and the national labs in order to provide continuity, stability, and long-range planning in the university sector as well as in the national lab sectors.

## IV. User Facility Program

With regard to the support functions relating to "the education and training of scientists and engineers" * more needs to be said. The report refers to "providing opportunities...at the laboratories" for such purposes but little is said about the funding appropriate to providing these opportunities. It is our understanding that the facilities at the laboratories usable for university research are typically only 40% utilized and only a fraction of this utilization is performed by university personnel (as opposed to laboratory personnel). Somehow this seems like an enormous waste of costly government-owned facilities and the budget for user support of those facilities, especially by the universities, should be augmented. Funds must be made available for travel and support of faculty and graduate students on-site, but in addition for the necessary instrumentation and supplies to be used by these university personnel in the pursuit of research to be performed at the labs.

One way to provide this much needed augmentation is to reprogram some of the money now directed toward development of new facilities into

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*Page 41, third bullet of Volume I of the ERAB final report.

this user-support augmentation program. In the opinion of this subcommittee, it is more important to more fully use the facilities now in existence than to provide all of the new facilities now being requested. Of course, if sufficient funds are available, the subcommittee strongly urges that both be done -- new state-of-the arts facilities (accelerators, fusion-devices, instrumentation, etc.) as well as user support and facility operation.

V. Comments On ERAB Report on Multi-program Laboratories

- A major element of the charge to ERAB was to review and appraise "The appropriate role and missions of the laboratories vis-a-vis industry and universities. No serious effort appears to have been made by the panel to obtain university perspectives from the university community.
- Although some laboratories are managed by a university or a consortium of universities, it does not follow that there is a strong and satisfactory working relationship between these labs and universities. Granted, the working relationship between these labs and the managing institution(s) may be satisfactory -- there can be problems between these same laboratories and other universities which are outside of the management relationship.

- In the ERDA-early DOE era the labs were strongly encouraged to expand their research activities beyond their basic missions and strengths to include other areas of energy research. The labs were quick to expand their facilities, equipment and staff to enter new areas of energy research. Universities, also a major research performer, were not given similar encouragement, equipment, facilities or staff, so that a preferential imbalance in capabilities was created. This has had the effect of favoring the national laboratories in program continuity and versatility in comparison to the universities.

- The institutional planning process of the labs is an iterative process between DOE and the labs that influences research directions of the labs and future suport for the labs. Universities do not receive similar preferential consideration from DOE. Specific emphasis on labuniversity relations have not been a part of this process. Universities have not participated as reviewers-evaluators of these lab institutional plans.
- The "so-called" lead laboratory concept of DOE places certain labs in a position of both managing the allocation of national resources for the support of R&D and of being a performer in these same R&D areas, strongly suggesting a conflict of interest. The allocation and performing roles should be separated. There is a suggestion of quid-pro-quo among labs functioning in lead lab roles.

- The panel suggests a more active role of labs in shaping national policies and programs. The labs, as performers of research and to the exclusion of other performers (universities & industry), face a conflict of interest in providing planning and policy assistance to DOE which might affect the subsequent allocation of DOE R&D funds.

- Under assessment of capabilities (p46) there is a statement that suggests that research in the labs compares favorably with that in universities. Given the preferred treatment that labs receive, shouldn't they perform much better than universities?

- A lot of university faculty and students who count as bodies in the statistical analysis of "university participation" in lab programs are not a part of a university research program and the participation is not the result of joint university lab planning. There is relatively little university input to planning of lab research using university faculty and students (except for programs on major user facilities). These participants' efforts are (more often than not) not tied to support of ongoing research at universities. The labs use university personnel to extend their own research objectives.

We recommend:

- Conduct a critical study of university-lab relations;
- develop improved rapport between DOE and universities to assure university inputs into DOE/national policies and plans;
- provide a forum for discussing university-lab relations;
- for allocation of Federal resources except for major national user facility programs, place labs in direct competition with universities and industry for allocation of DOE research dollars;
- require labs to utilize university personnel in process of reviewing lab plans, policies and procedures;
- DOE should stimulate (or mandate) stronger and more acceptable efforts of labs to involve universities in cooperative research, with joint planning, etc.

Table 2.2. Distribution of DOE R&D budget obligation by performer
($ in millions)

| FY | Total | Intramural | Industrial firms | Universities and colleges | Other nonprofit | State and local governments | Foreign | All FFRDCs[a] | Nine laboratories (Gross)[b] | Nine laboratories (Net)[c] |
|---|---|---|---|---|---|---|---|---|---|---|
| 1979 | 4638.8 | 361.9 | 1547.9 | 260.1 | 57.0 | 15.1 | 3.5 | 2393.4 | 2042 | 1344 |
| 1980 | 4753.7 | 473.6 | 1377.0 | 285.0 | 58.5 | 22.4 | 14.2 | 2523.0 | 2237 | 1405 |
| 1981[d] | 4926.7 | 516.7 | 1314.0 | 289.1 | 61.1 | 18.7 | 20.7 | 2706.3 | 2495 | 1553 |
| 1982[d] | 4690.2 | 366.8 | 1298.8 | 280.4 | 48.4 | 3.4 | 9.1 | 2683.3 | 2499 | |

[a] Federally funded research and development centers.

[b] From Tables 2.8 to 2.11. Note that these numbers are inconsistent with NSF's data (i.e., NSF does not count all of DOE's "R&D budget" as R&D).

[c] Net budget equals gross budget from previous column after subtraction of subcontracting and procurement of Table 2.3.

[d] Estimated.

Source: National Science Foundation except as noted above.

Table 2.20. Performer share of DOE energy
R&D Budget for FY 1981
($ in millions)

| | Nine laboratories (%) | Other DOE (%) | Industry and Other (%) | University (%) | Federal laboratories (%) | Total |
|---|---|---|---|---|---|---|
| General Science | 235.8 (45) | 191.9 (37) | 3.2 ( 1) | 88.5 (17) | 0.9 (<1) | 520.3 |
| Solar, geothermal, electrical energy, and storage | 180.6 (23) | 129.6 (17) | 354.1 (46) | 20.3 ( 3) | 87.3 (11) | 771.7 |
| Fusion | 185.0 (47) | 140.5 (36) | 31.0 ( 8) | 33.9 ( 9) | 3.1 ( 1) | 393.6 |
| Nuclear | 235.3 (20) | 414.7 (35) | 540.7 (45) | 6.6 ( 1) | 1.4 (<1) | 1198.5 |
| Environment | 82.2 (50) | 45.0 (27) | 9.1 ( 5) | 21.7 (13) | 7.5 ( 5) | 165.6 |
| Supporting research | 159.2 (65) | 1.4 ( 1) | 19.9 ( 8) | 60.5 (25) | 4.6 ( 2) | 245.7 |
| Fossil | 76.8 (10) | 67.7 ( 8) | 608.6 (76) | 35.5 ( 4) | 14.5 ( 2) | 803.2 |
| Conservation | 55.7 (25) | 3.5 ( 2) | 88.6 (39) | 4.4 ( 2) | 74.5 (33) | 226.6 |
| Total | 1210.6 (28) | 994.3 (23) | 1655.2 (38) | 271.4 ( 6) | 193.8 ( 4) | 4325.2 |

Source: DOE Program Office Data.

### Table 2.21. Performer share of DOE energy R&D budget for FY 1982 ($ in millions)[a]

| | Nine laboratories (%) | Other DOE (%) | Industry and Other (%) | University (%) | Federal laboratories (%) | Total |
|---|---|---|---|---|---|---|
| General Science | 223.0 (41) | 212.3 (39) | 15.4 ( 3) | 93.2 (17) | 1.9 (<1) | 545.8 |
| Solar, geothermal, electrical energy, and storage | 102.5 (30) | 40.6 (12) | 140.5 (41) | 17.7 ( 5) | 44.9 (13) | 346.1 |
| Fusion | 220.8 (49) | 148.6 (33) | 40.6 ( 9) | 41.1 ( 9) | 2.7 ( 1) | 453.8 |
| Nuclear | 241.1 (20) | 424.6 (36) | 506.5 (43) | 4.7 (<1) | 3.2 (<1) | 1180.0 |
| Environment | 75.8 (46) | 42.3 (26) | 17.8 (11) | 24.2 (15) | 4.8 ( 3) | 165.0 |
| Supporting Research | 173.5 (68) | 1.1 (<1) | 13.2 ( 5) | 64.3 (25) | 4.6 ( 2) | 256.7 |
| Fossil | 48.2 (12) | 60.2 (14) | 271.3 (65) | 18.8 ( 4) | 19.8 ( 5) | 418.2 |
| Conservation | 52.4 (31) | 2.7 ( 1) | 58.8 (35) | 1.9 ( 1) | 54.7 (32) | 170.4 |
| Total | 1137.3 (32) | 932.4 (26) | 1064.1 (30) | 265.9 ( 8) | 136.6 ( 4) | 3536.0 |

[a] Estimated.

Source: DOE Program Office Data.